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Sakamoto et al.

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(54) **TRANSFER METHOD, HOLDING APPARATUS, AND TRANSFER SYSTEM**

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Jan. 10, 2014 (JP) 2014-003675

(51) **Int. Cl.**

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B65H 5/10	(2006.01)
B65H 5/14	(2006.01)
B65H 5/04	(2006.01)
H05K 13/00	(2006.01)

(52) **U.S. Cl.**

CPC .. ***B65H 5/10*** (2013.01); ***B65H 5/04*** (2013.01); ***B65H 5/14*** (2013.01); ***H05K 13/0061*** (2013.01); ***H05K 13/0069*** (2013.01); *B65H 2801/61* (2013.01); *B65H 2801/72* (2013.01)

(58) **Field of Classification Search**

CPC H01L 21/00; H01L 21/67; H01L 21/68; H01L 21/673; H01L 21/683; H01L 21/67109; H01L 21/6831; H01L 21/68707; H01L 21/67051; H01L 21/687428

USPC 438/16, 778, 782; 29/740; 156/345.53

See application file for complete search history.

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Primary Examiner — Michael Lebentritt

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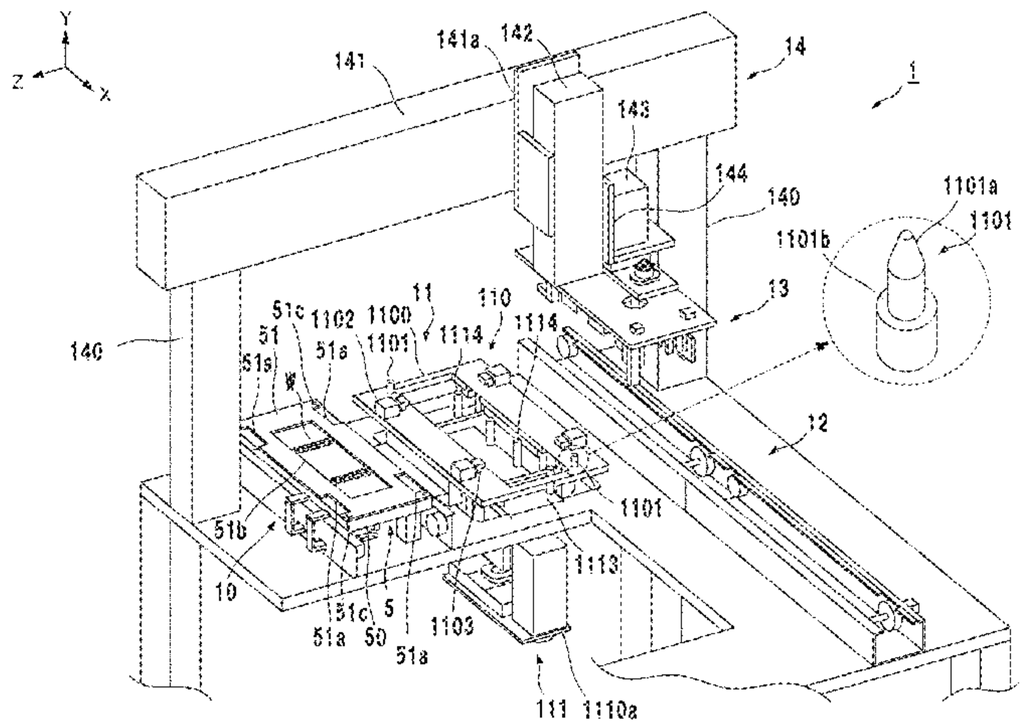
(57) **ABSTRACT**

This invention provides a transfer method of transferring, from a carrier including a placing portion on which a substrate is placed, and a cover that is superposed on the upper surface of the placing portion in close contact, the substrate held between the placing portion and the cover. The transfer method includes a holding step of holding the substrate and the cover on the placing portion by a holding apparatus, and a moving step of moving the holding apparatus to move the substrate and the cover from the placing portion to a transfer destination. In the holding step, the cover is held by the cover holding unit of the holding apparatus, and the substrate is held by the substrate holding unit of the holding apparatus in parallel postures of the cover and substrate.

10 Claims, 18 Drawing Sheets



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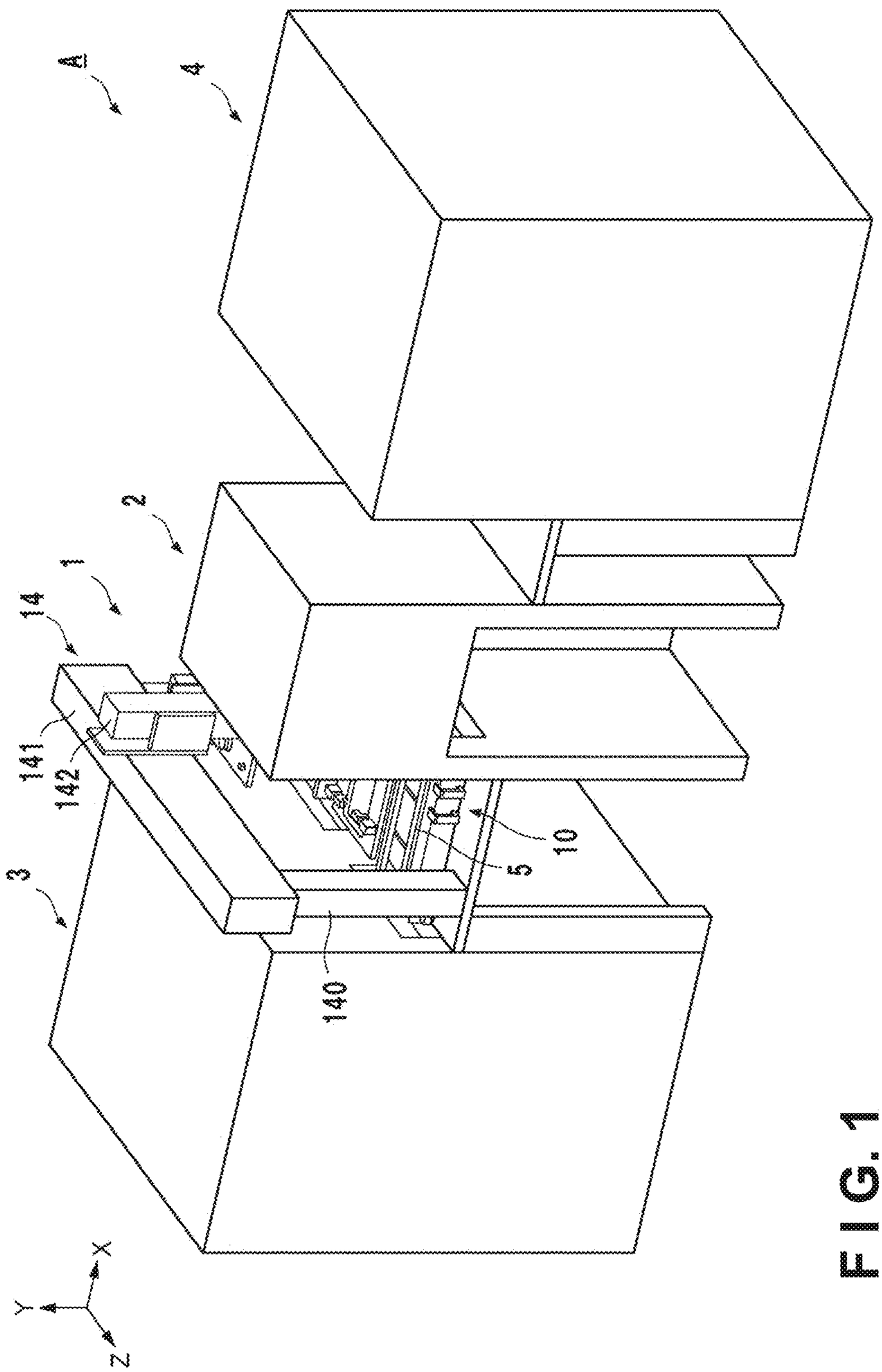

FIG. 1

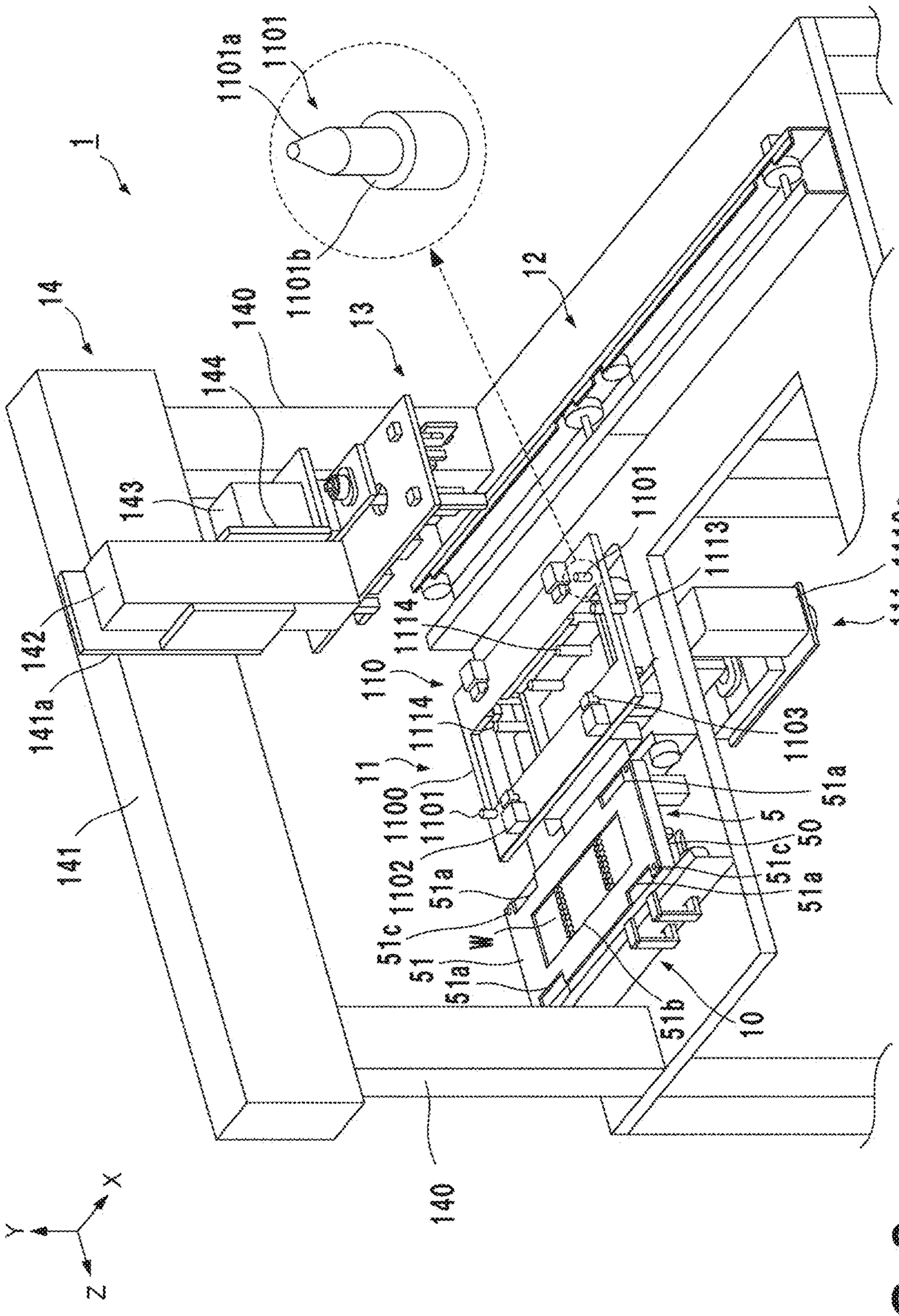
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FIG. 2

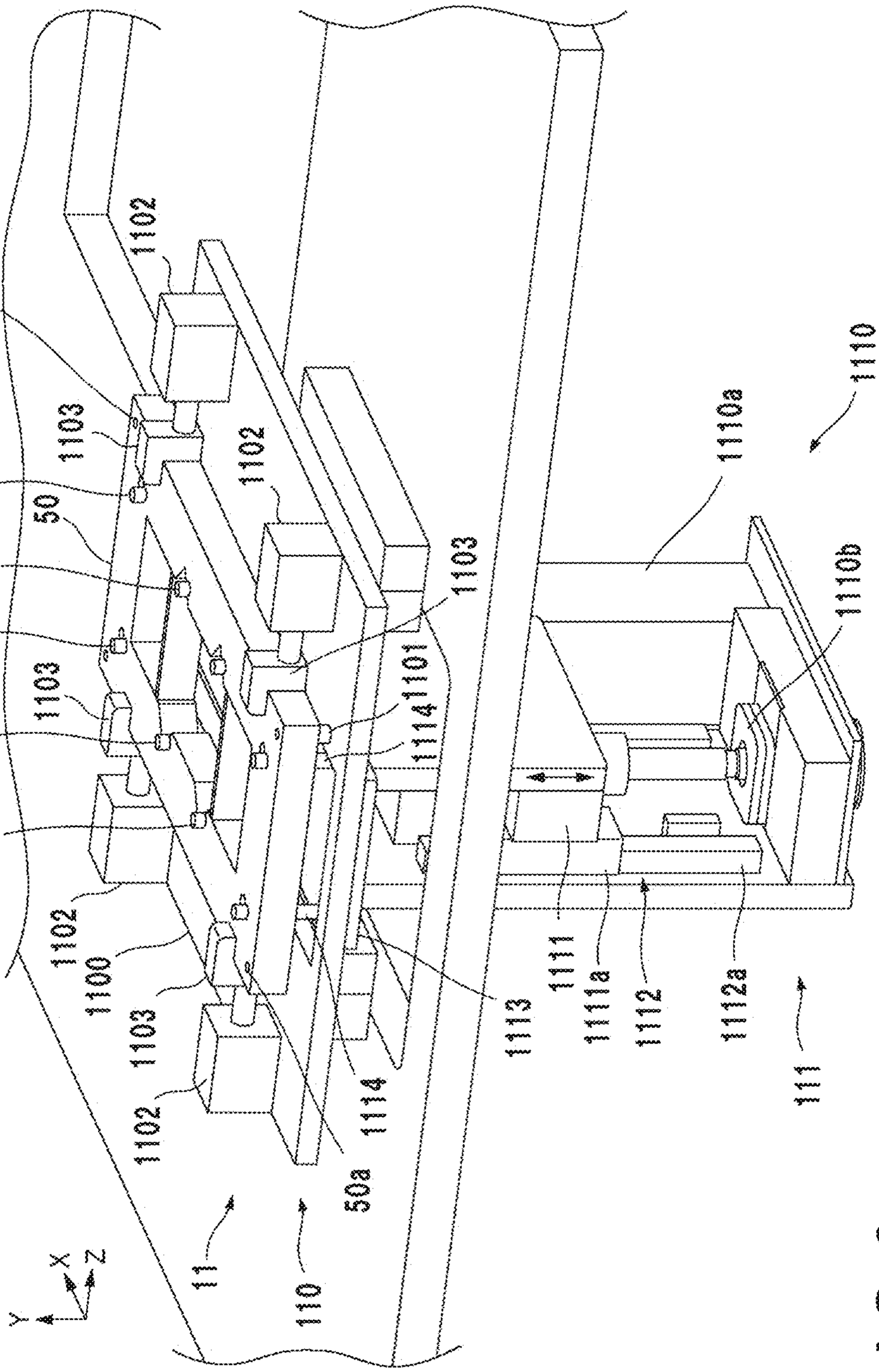
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FIG. 3

FIG. 4A

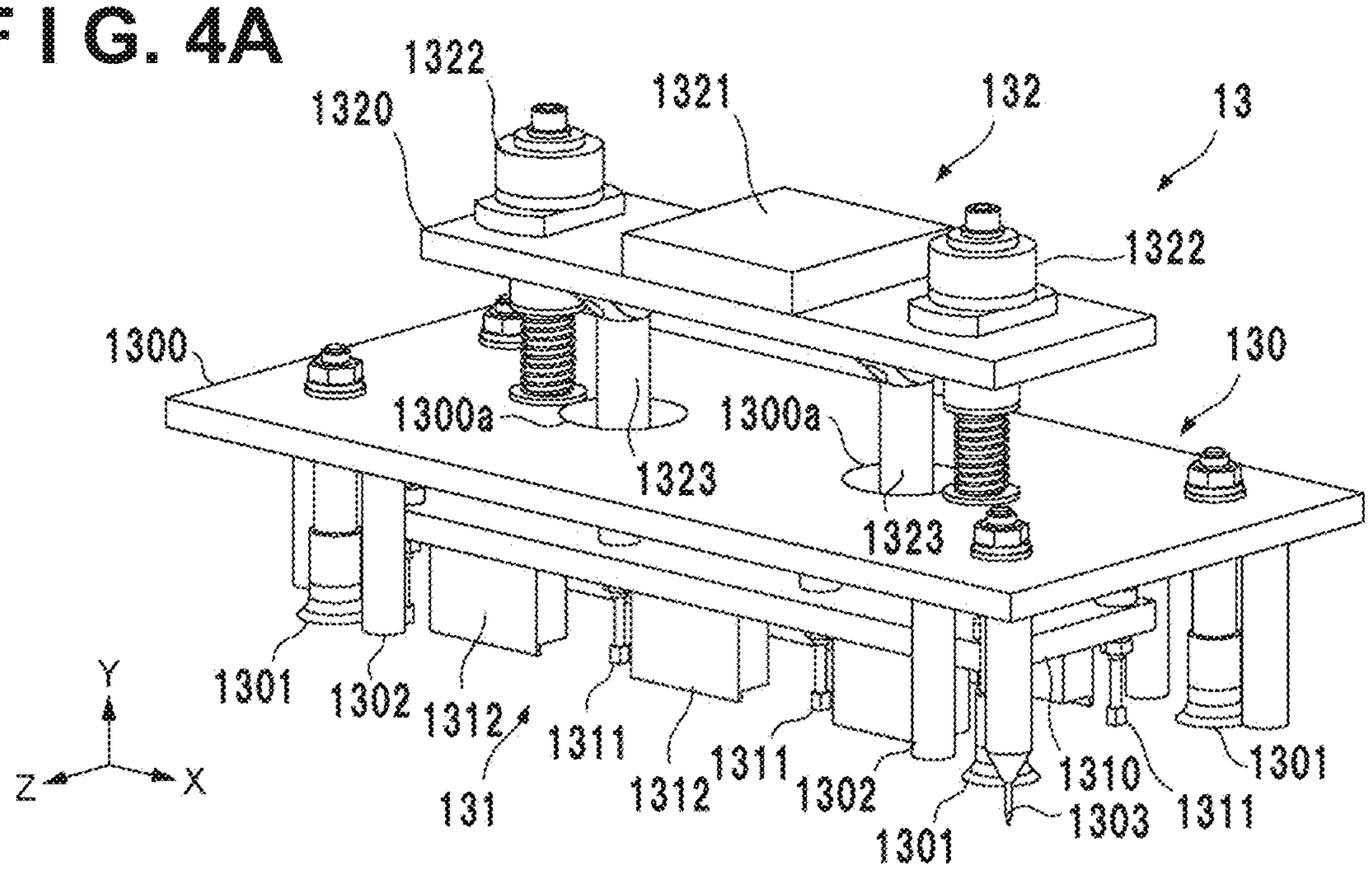
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FIG. 4B

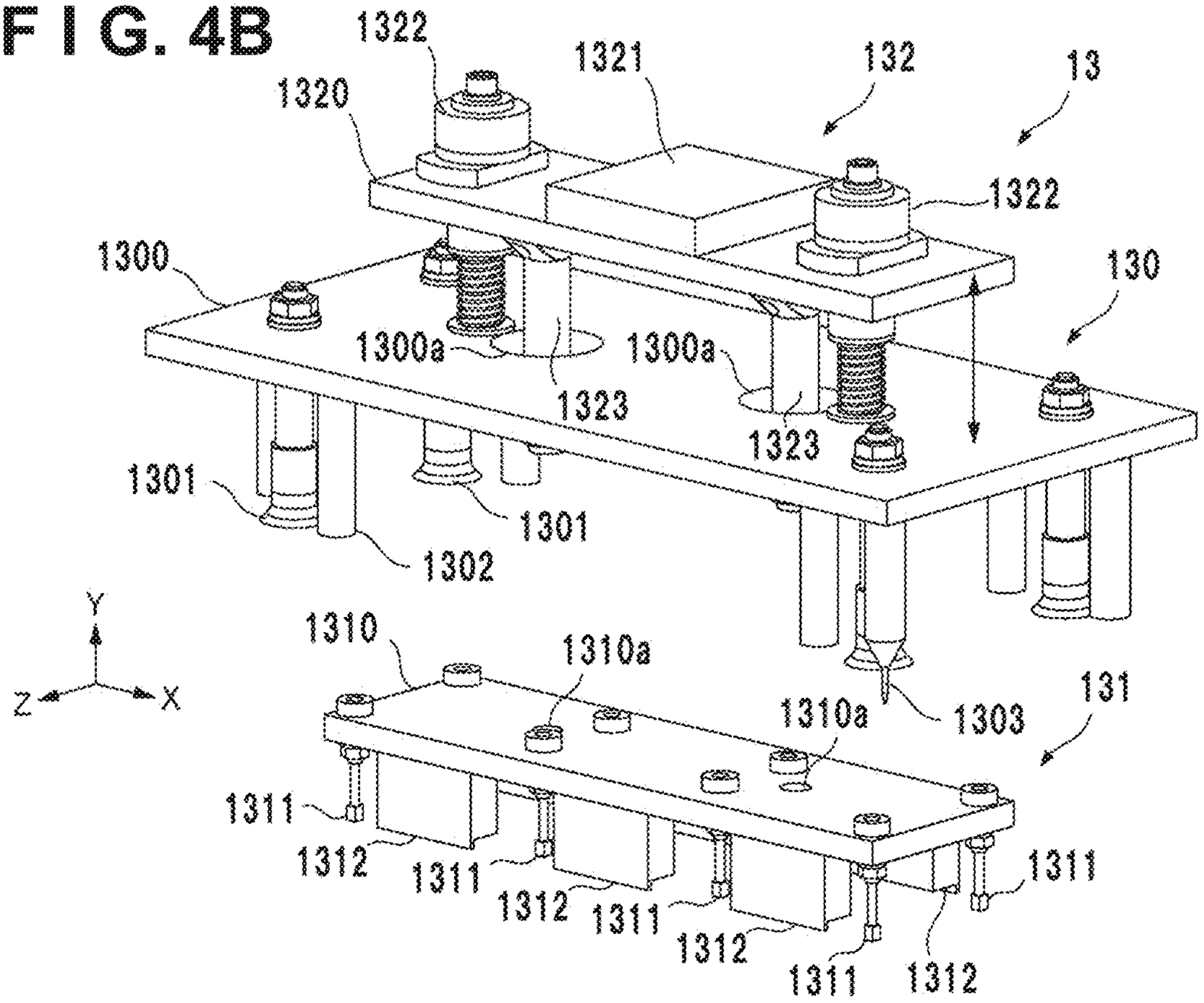
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FIG. 5A

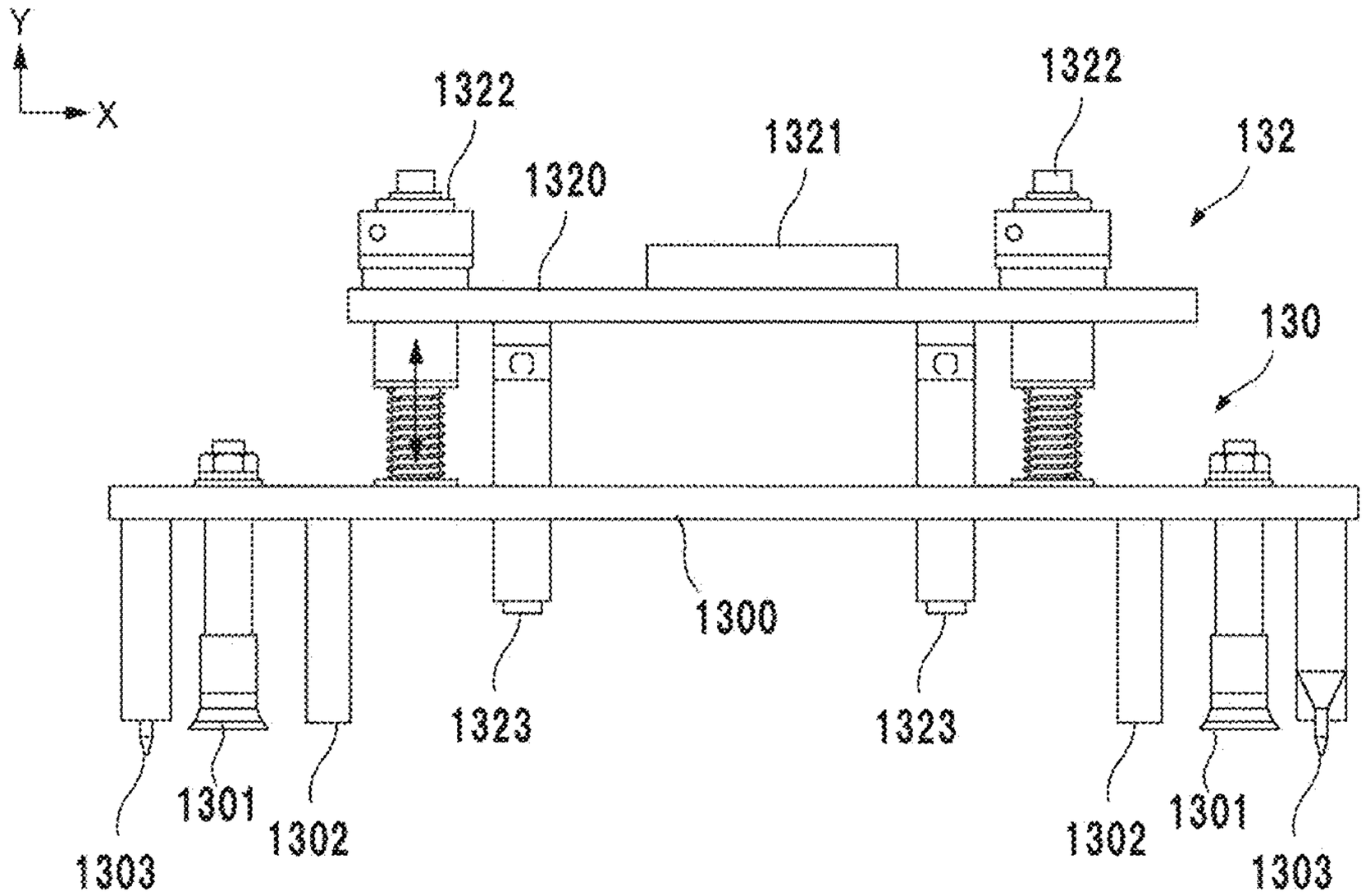
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FIG. 5B

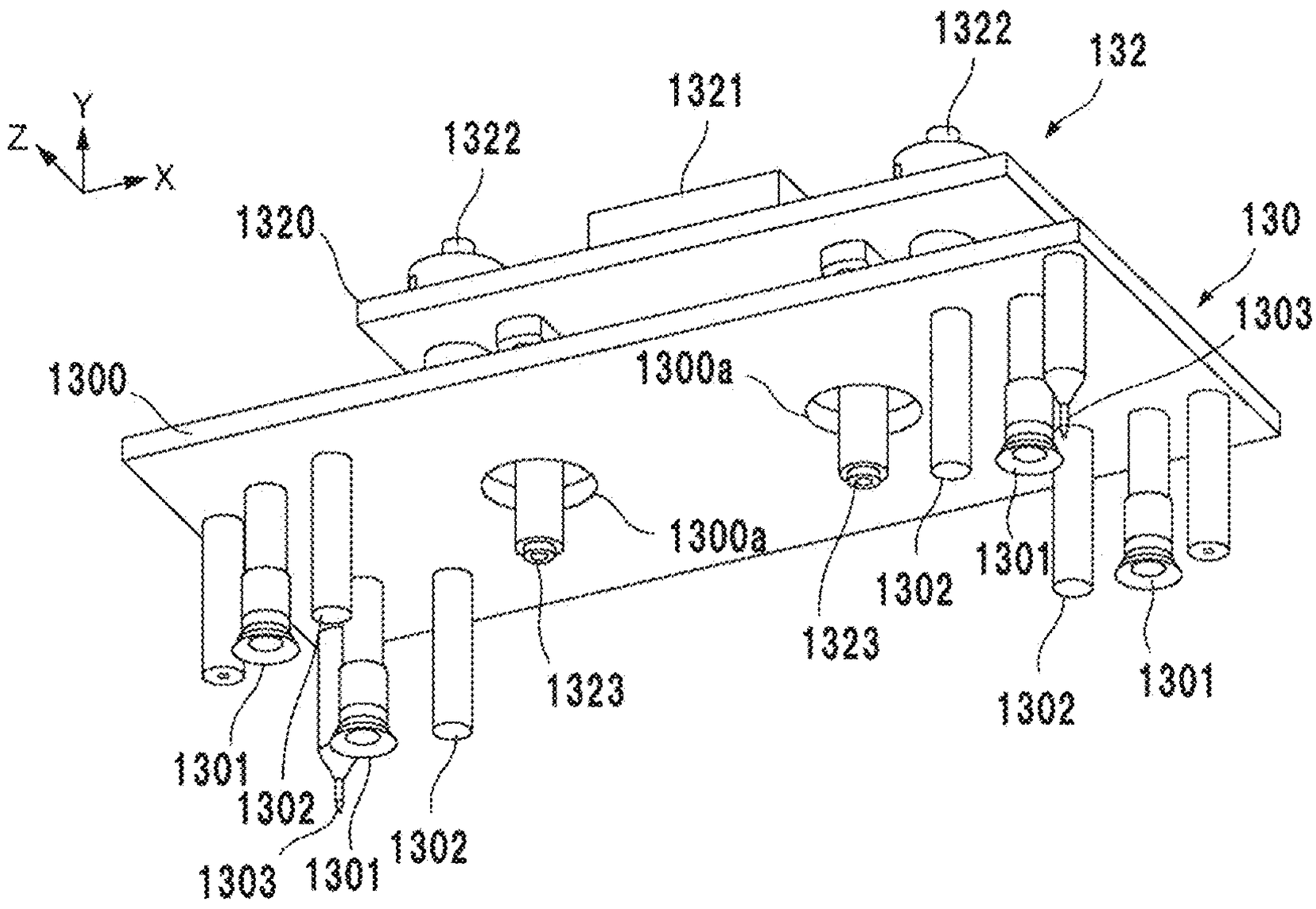
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FIG. 6A

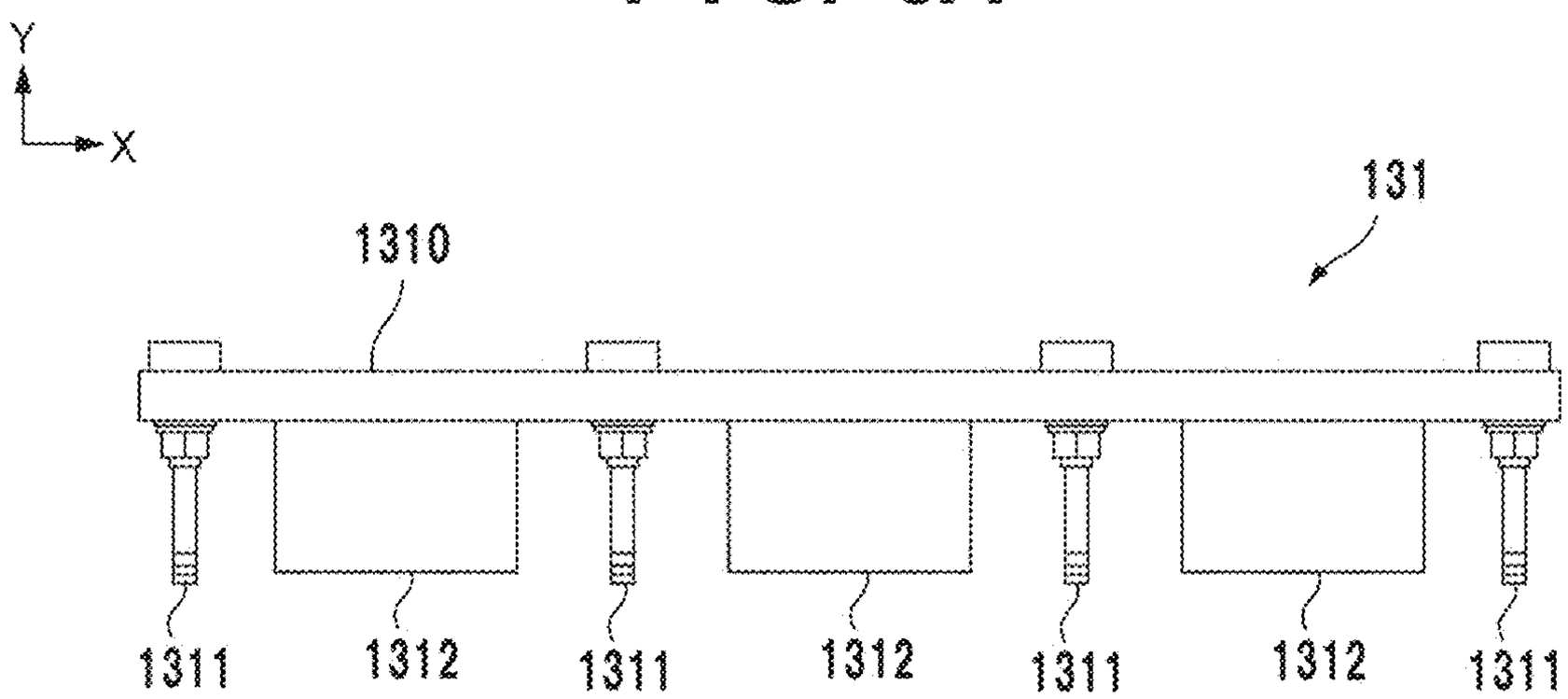
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FIG. 6B

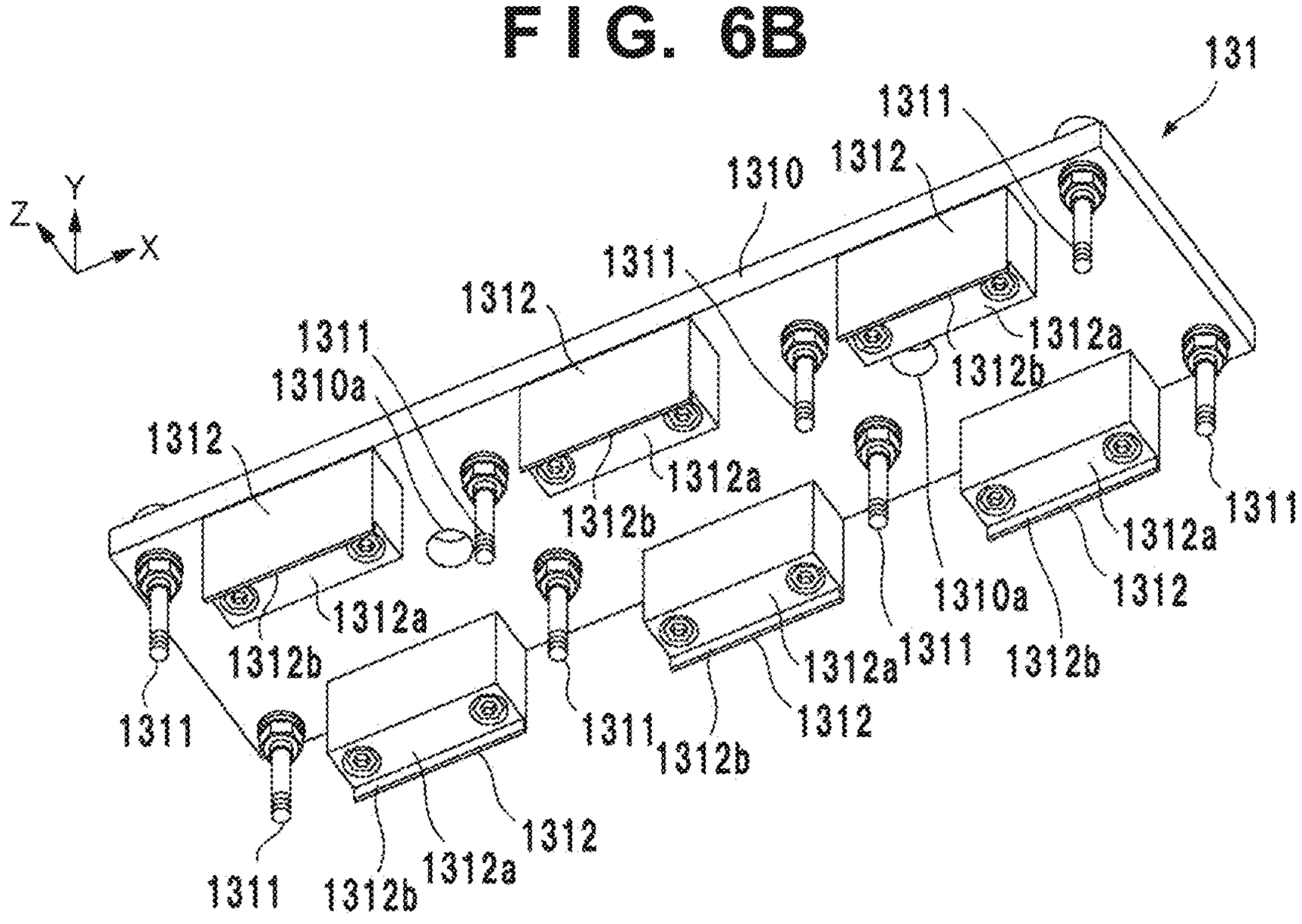
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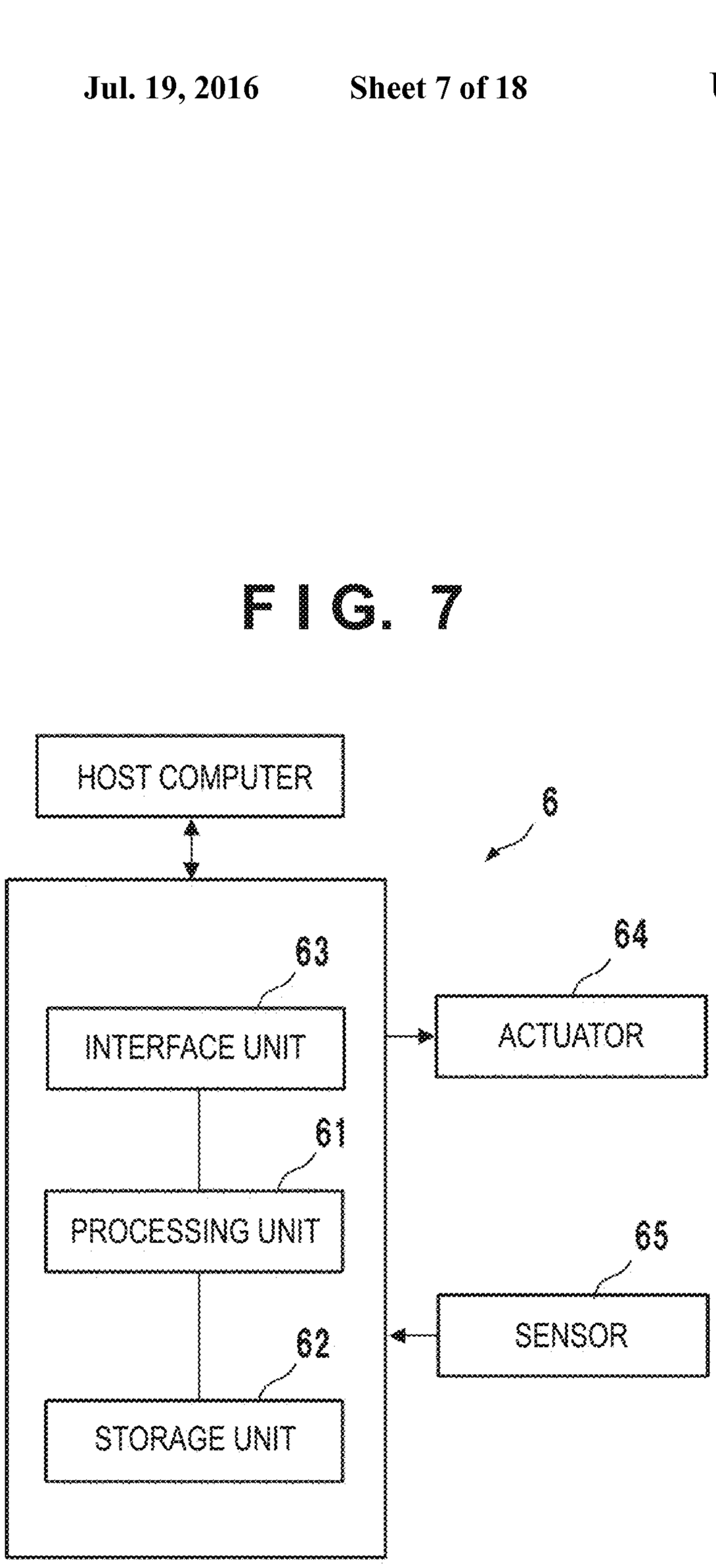
FIG. 7


HOST COMPUTER
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INTERFACE UNIT
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ACTUATOR
61
PROCESSING UNIT
65
SENSOR
62
STORAGE UNIT

FIG. 8A

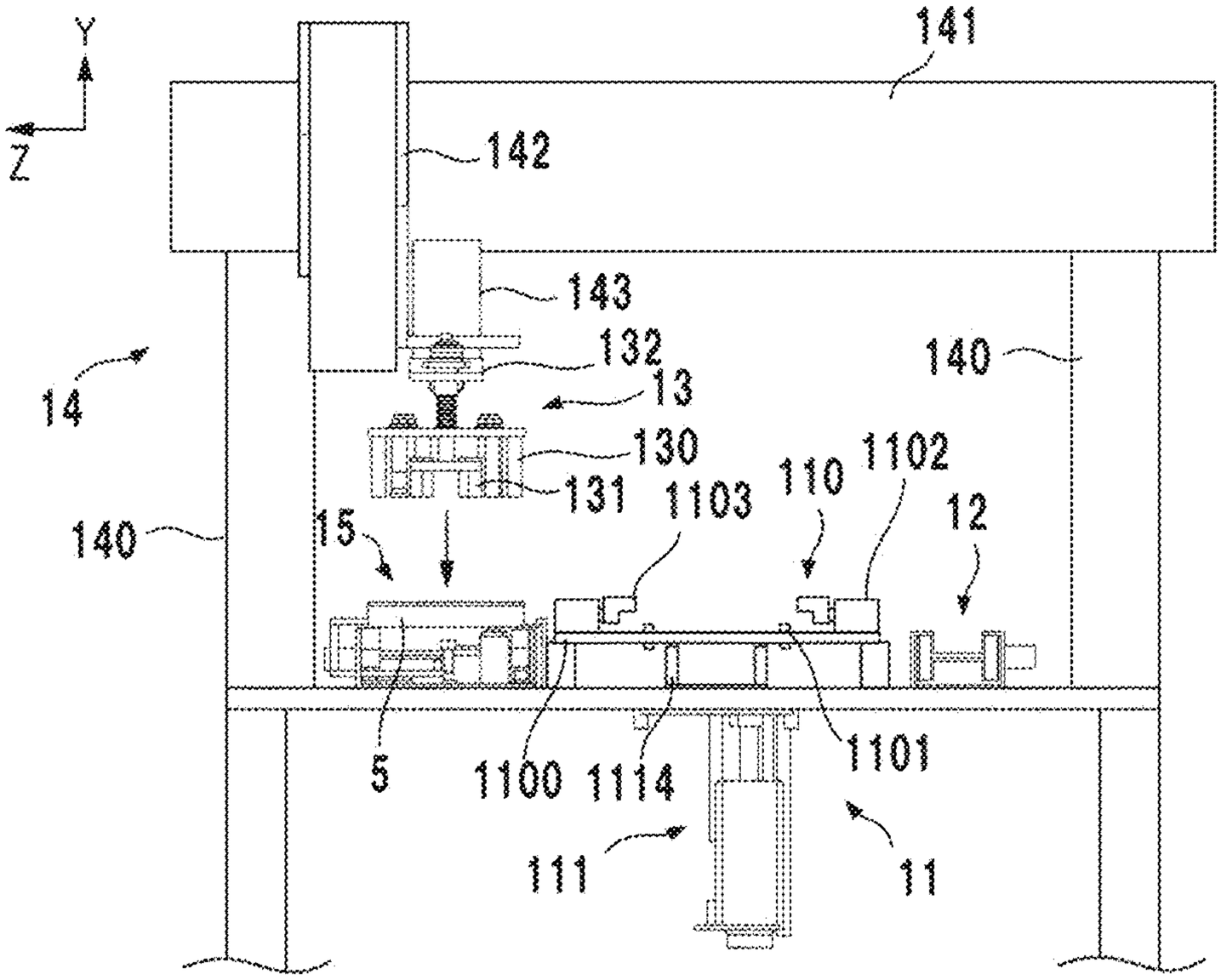
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FIG. 8B

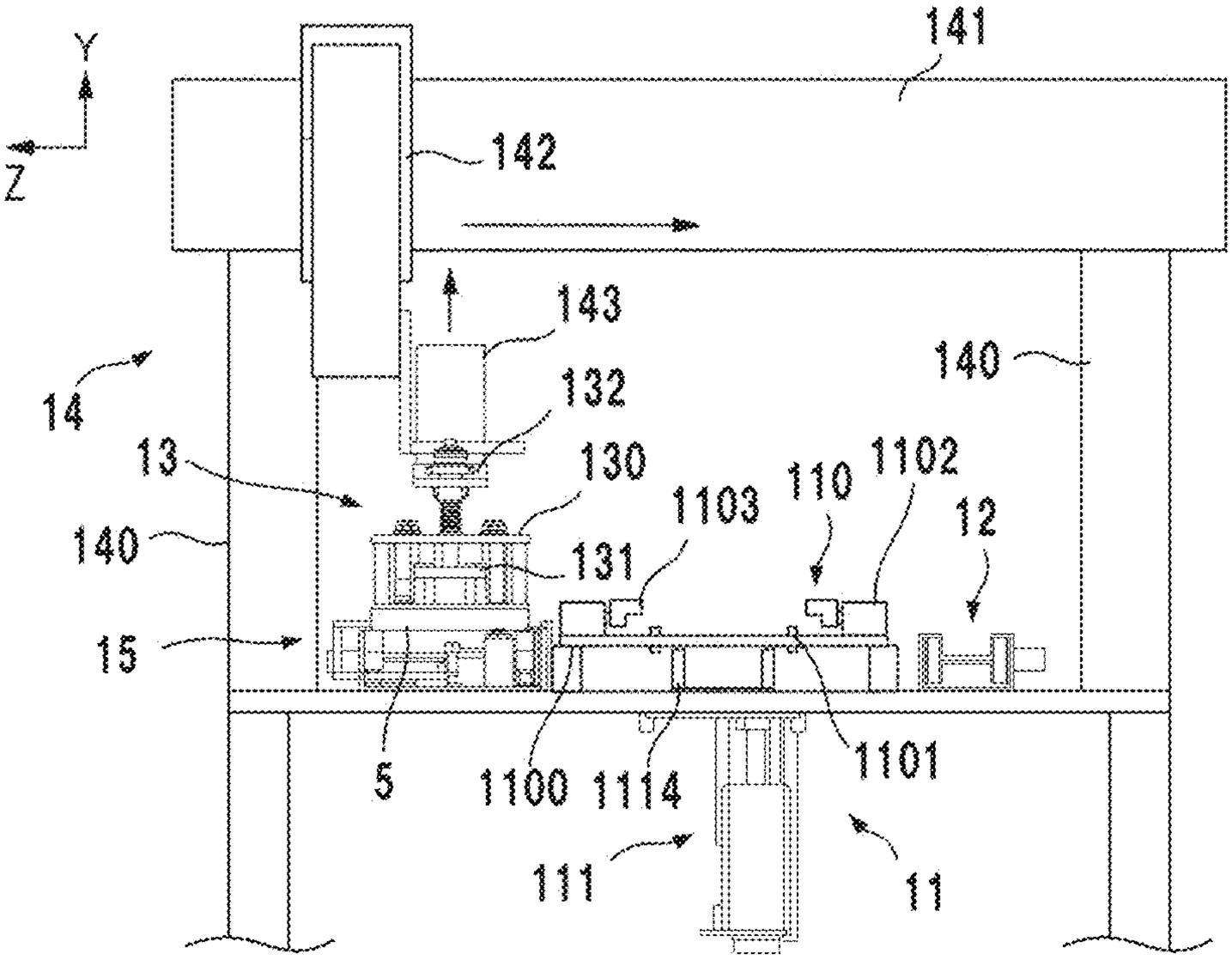
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FIG. 9A

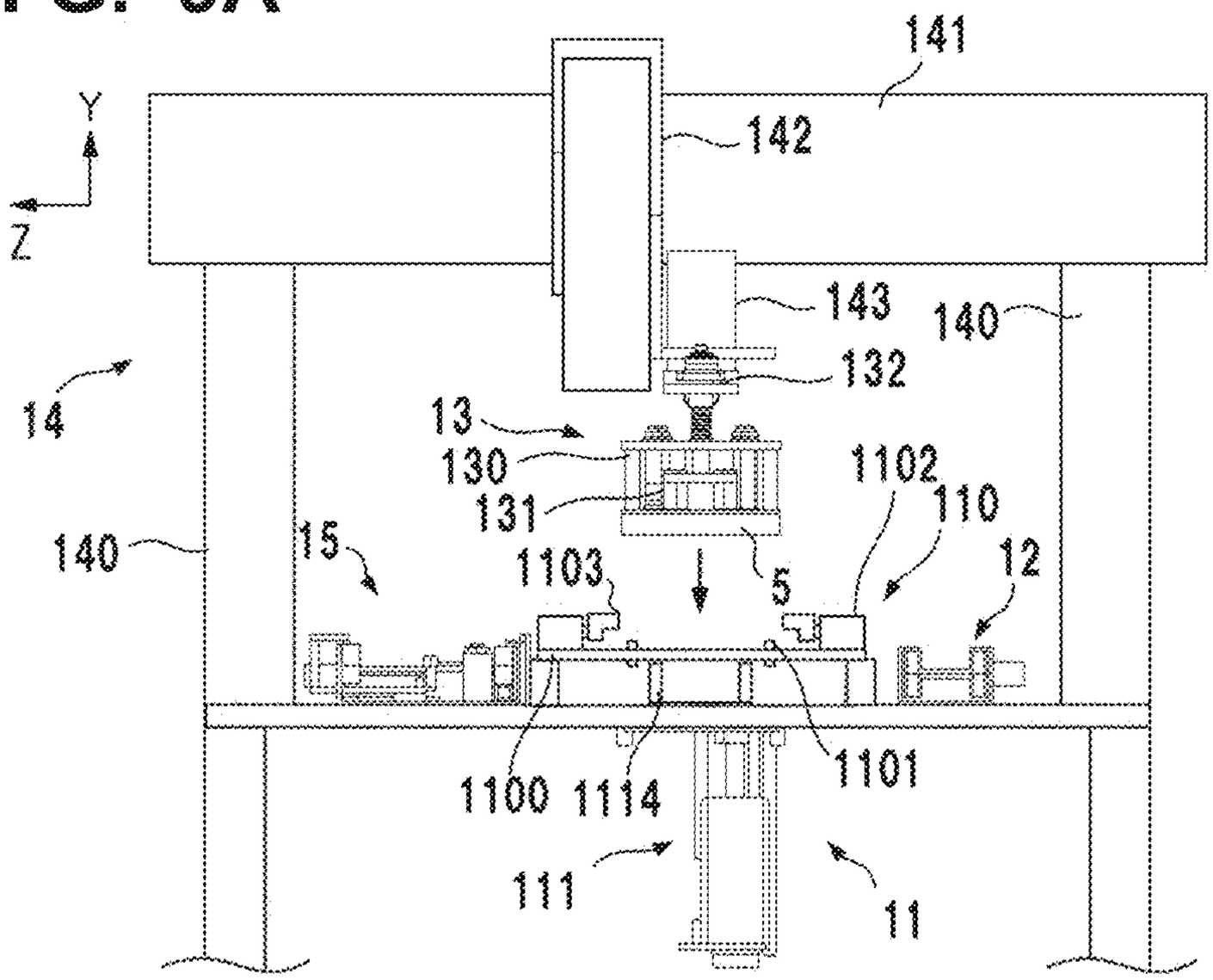
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FIG. 9B

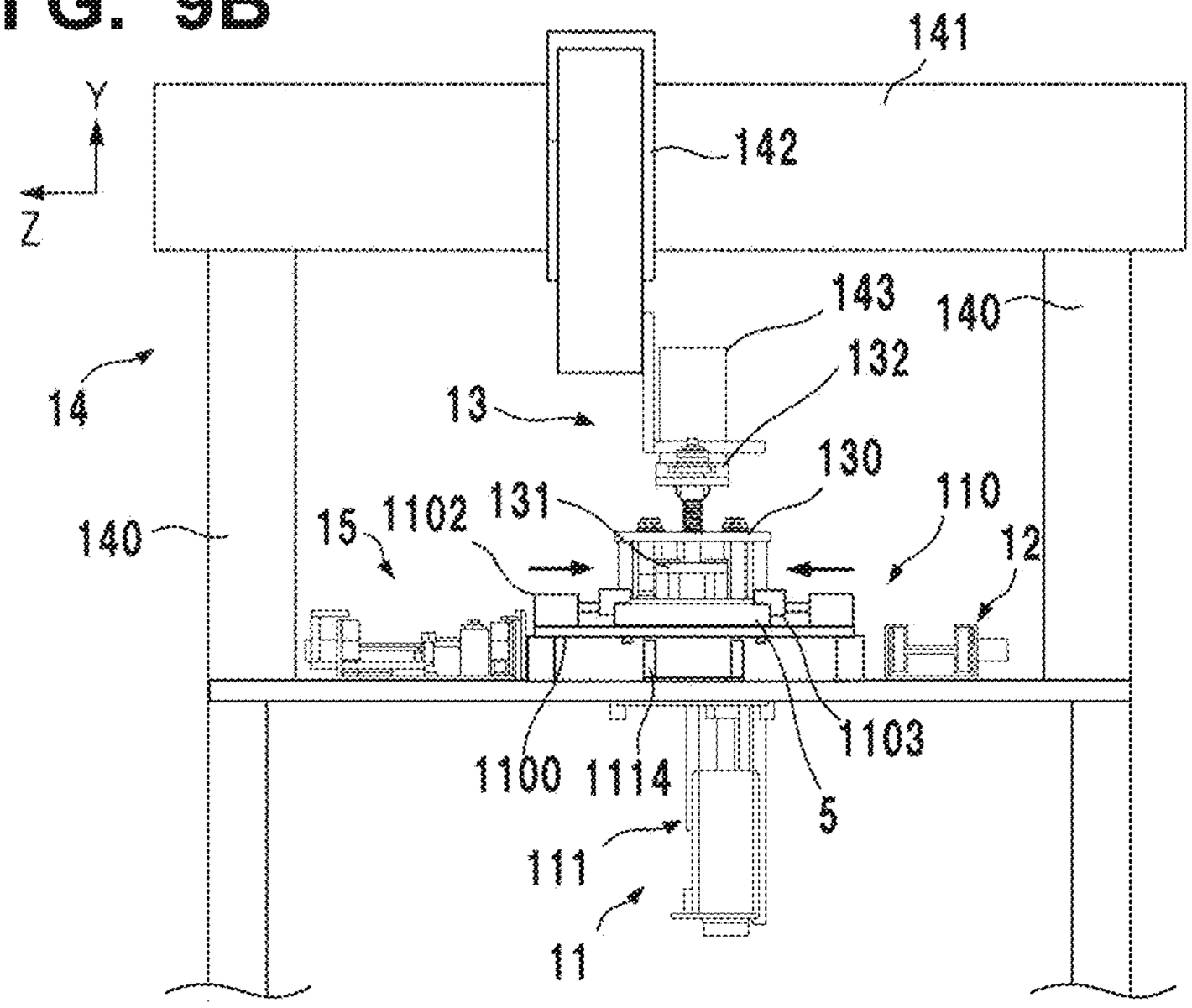
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FIG. 10A

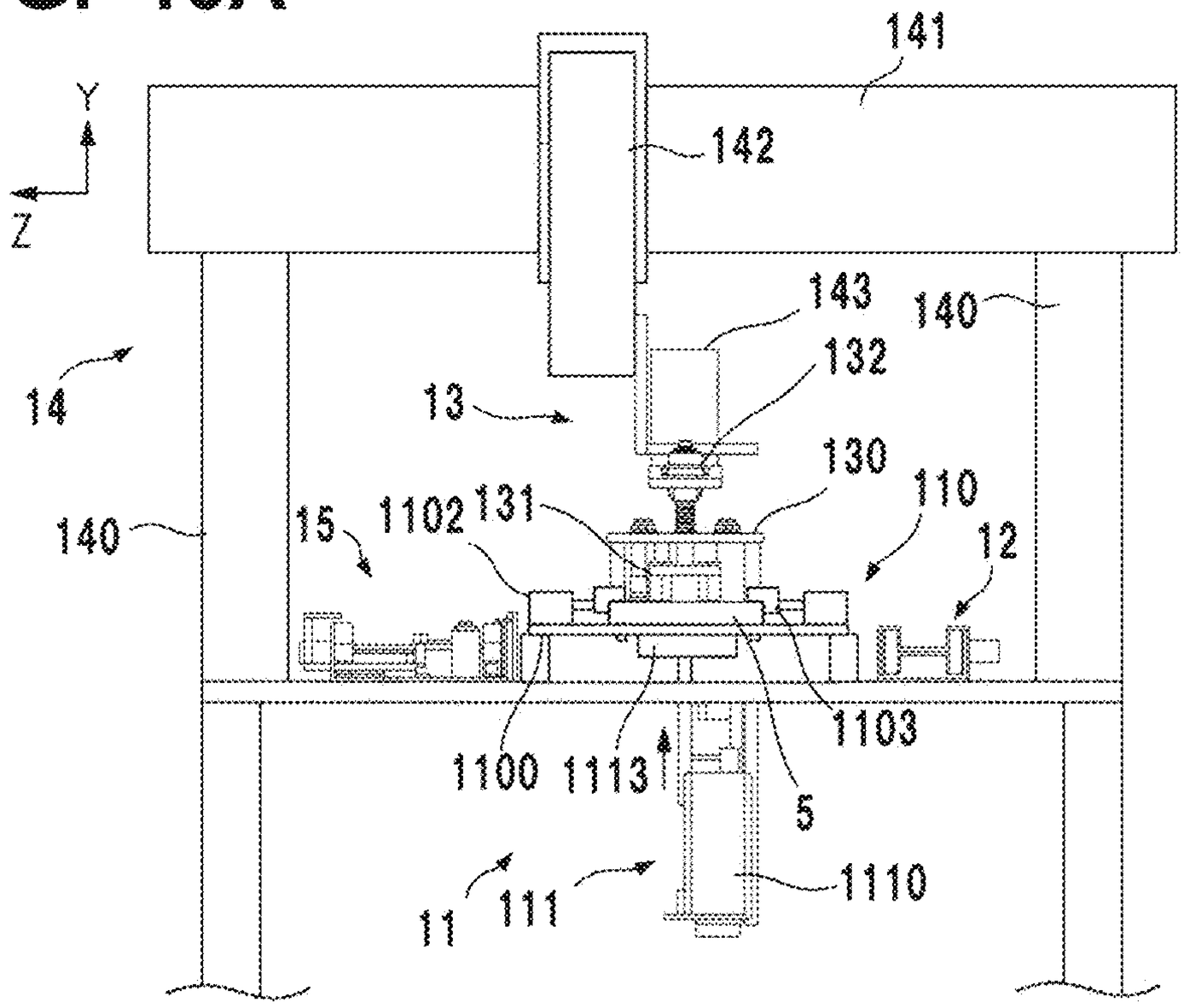

FIG. 10B

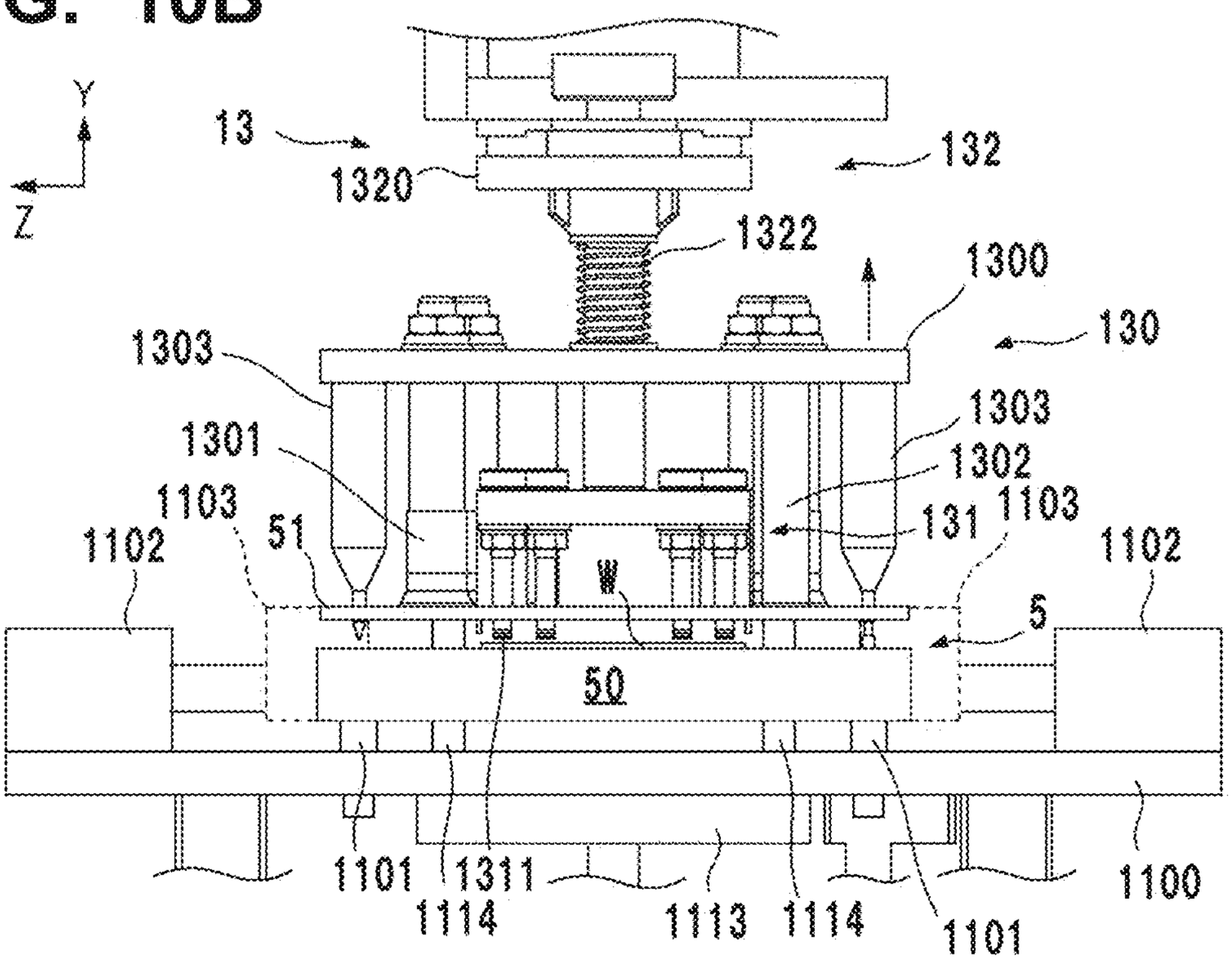

FIG. 11A

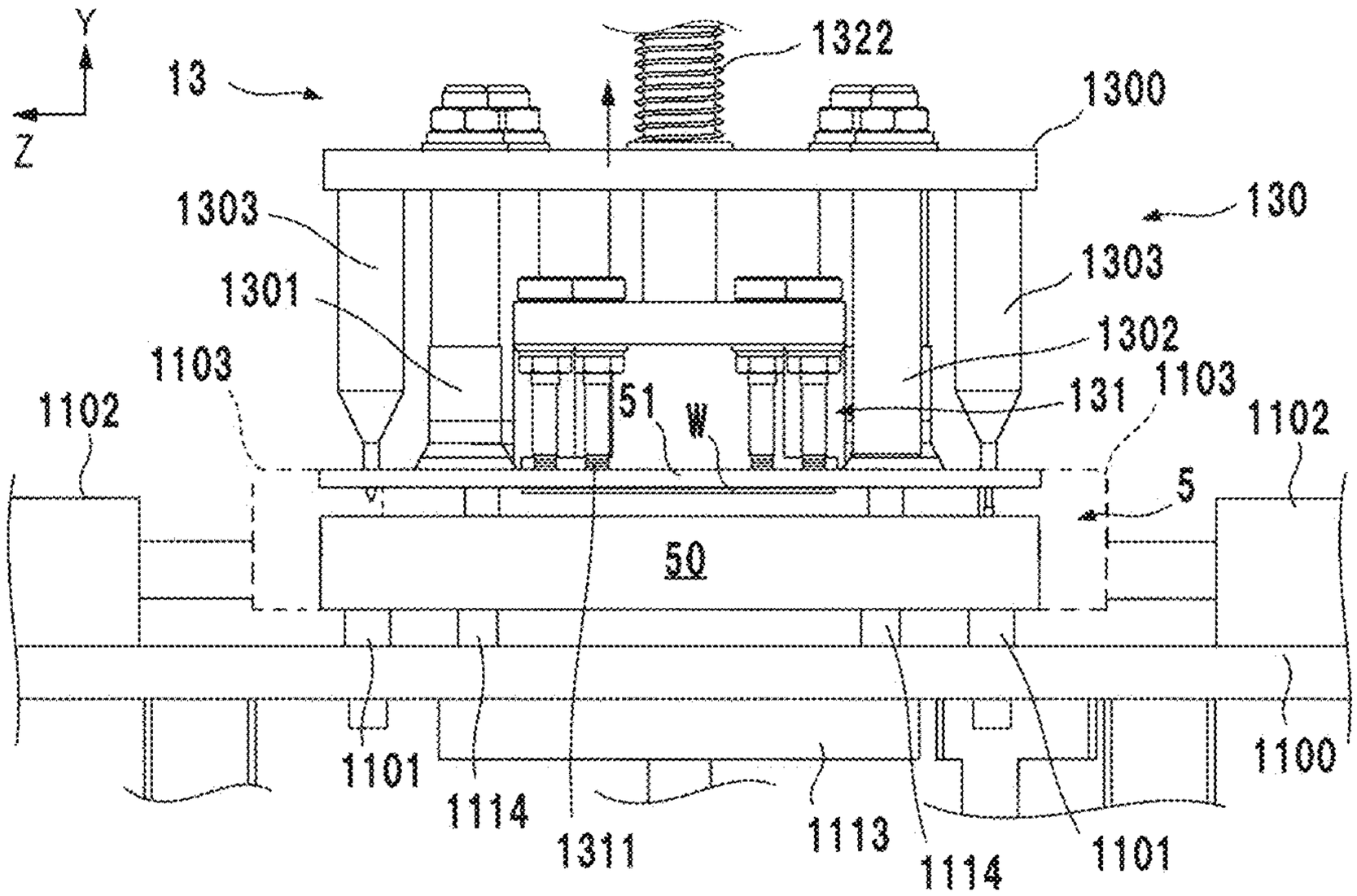

FIG. 11B

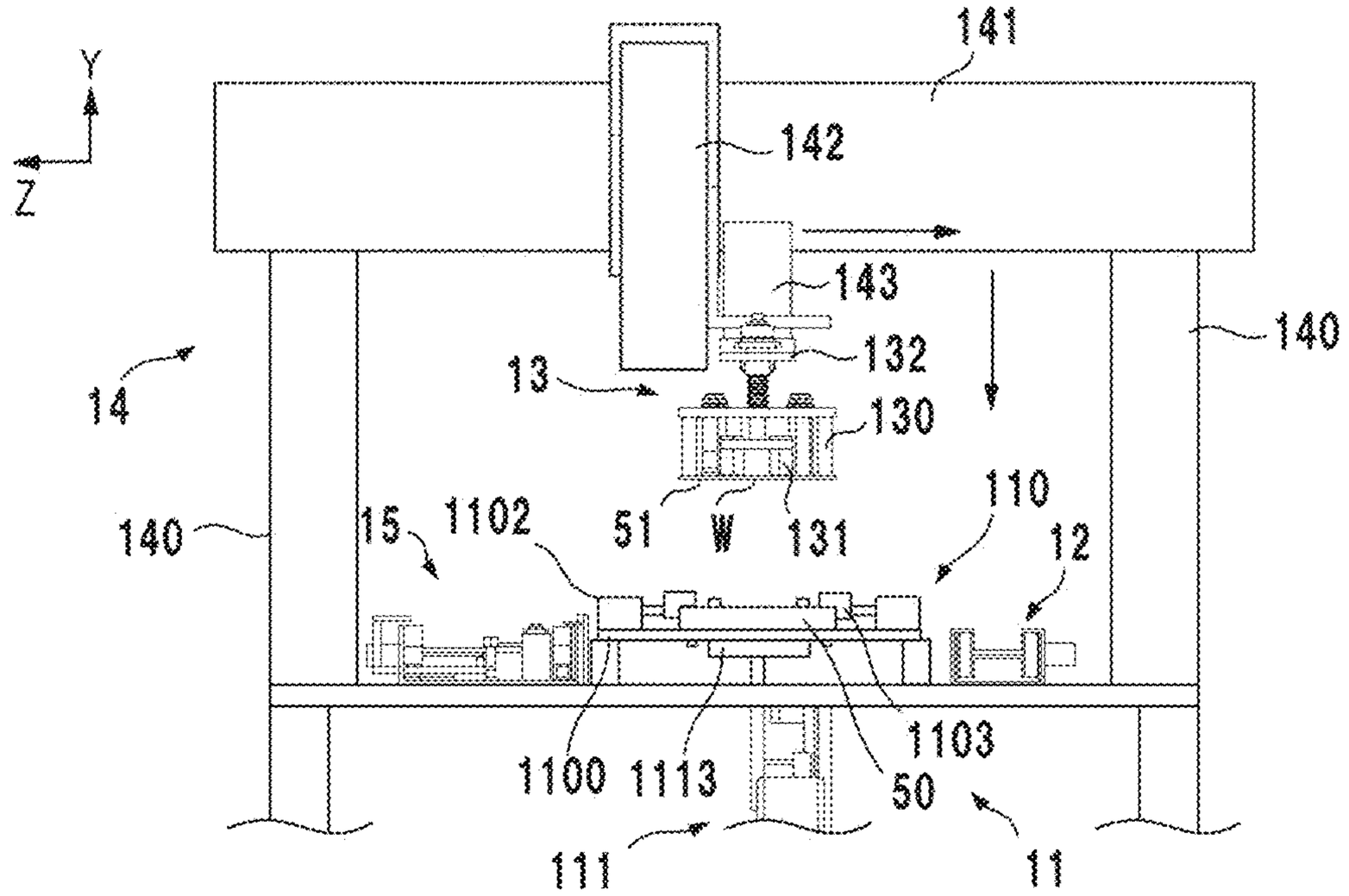

FIG. 12

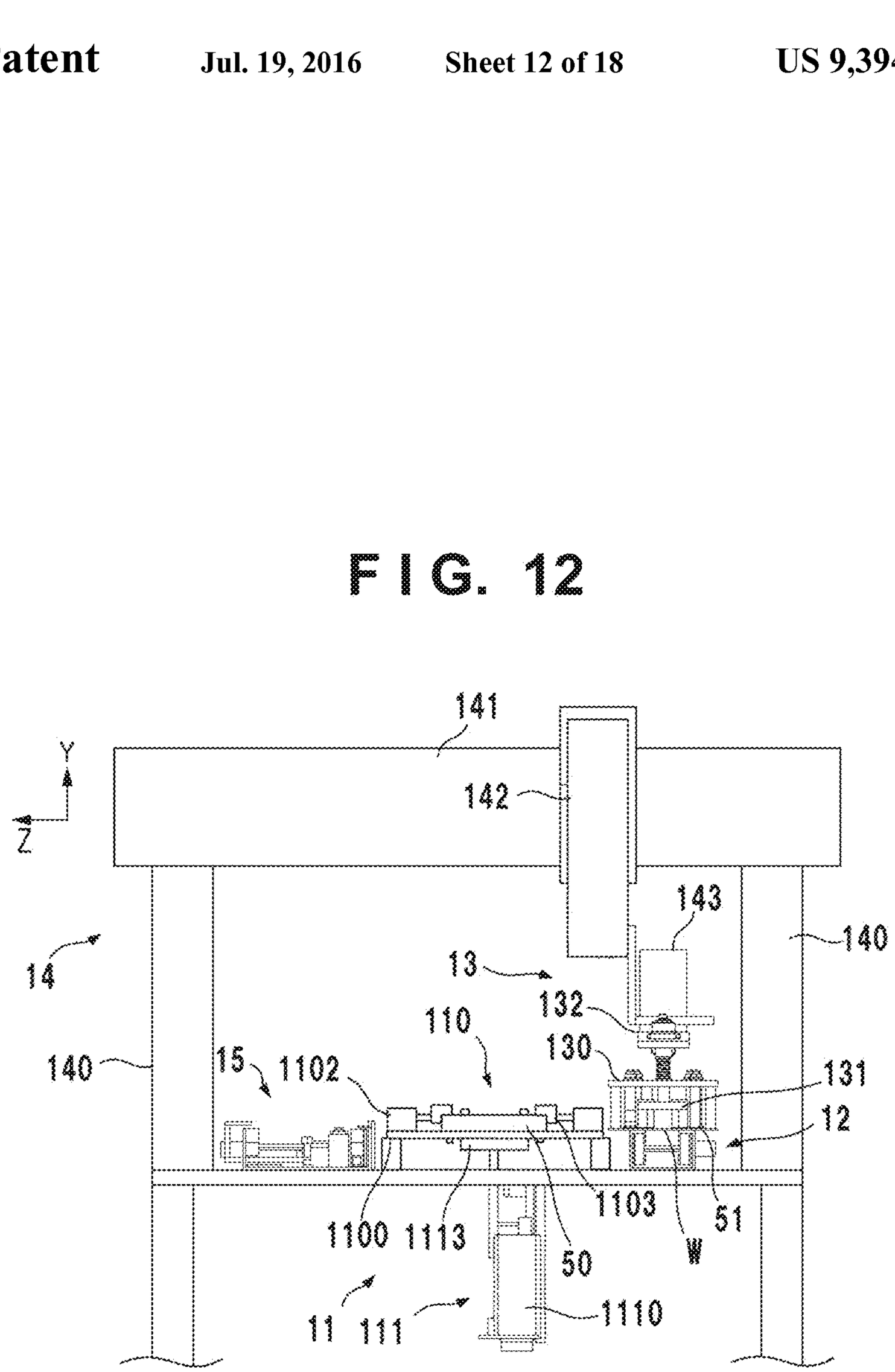
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FIG. 13A

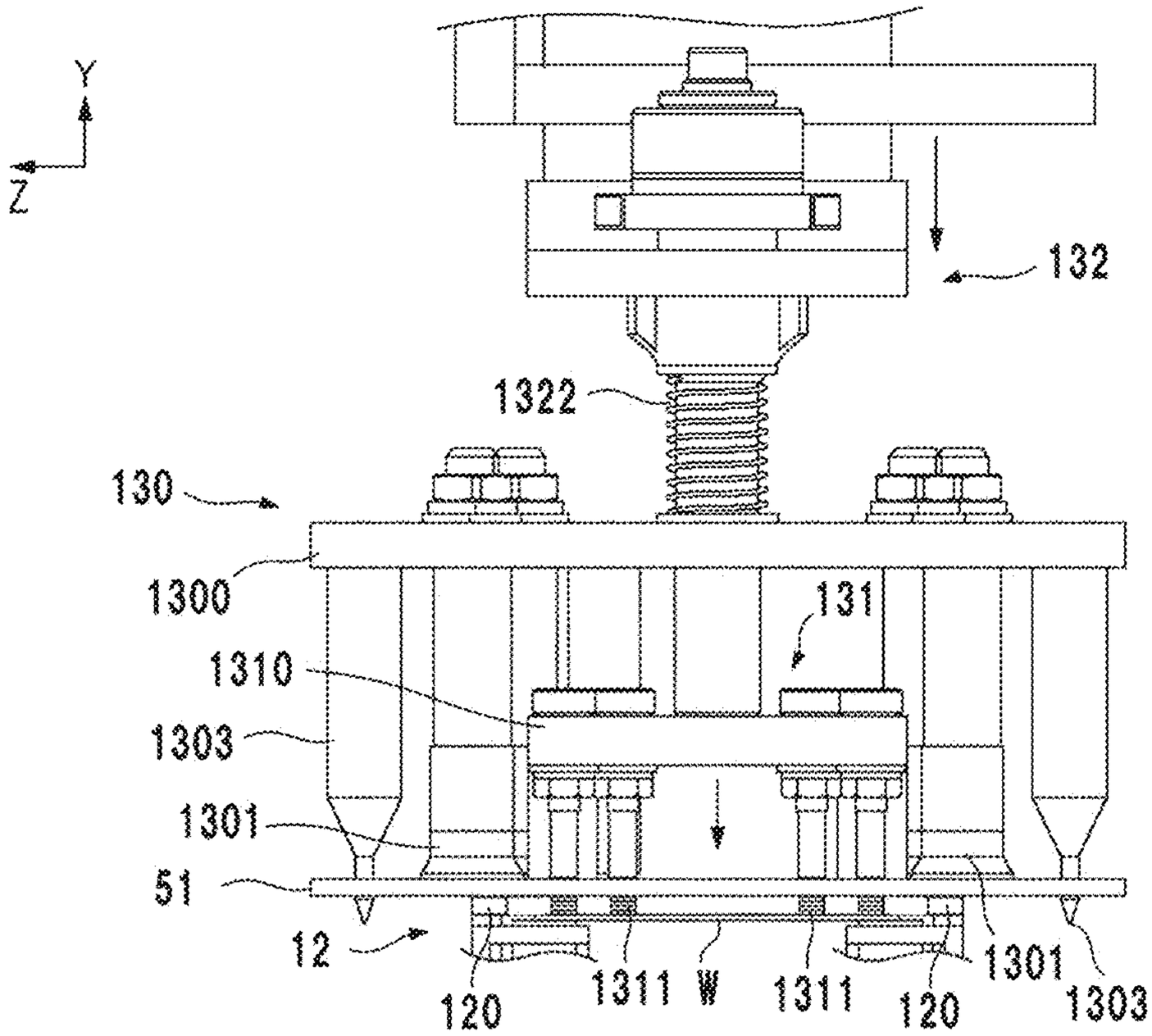

FIG. 13B

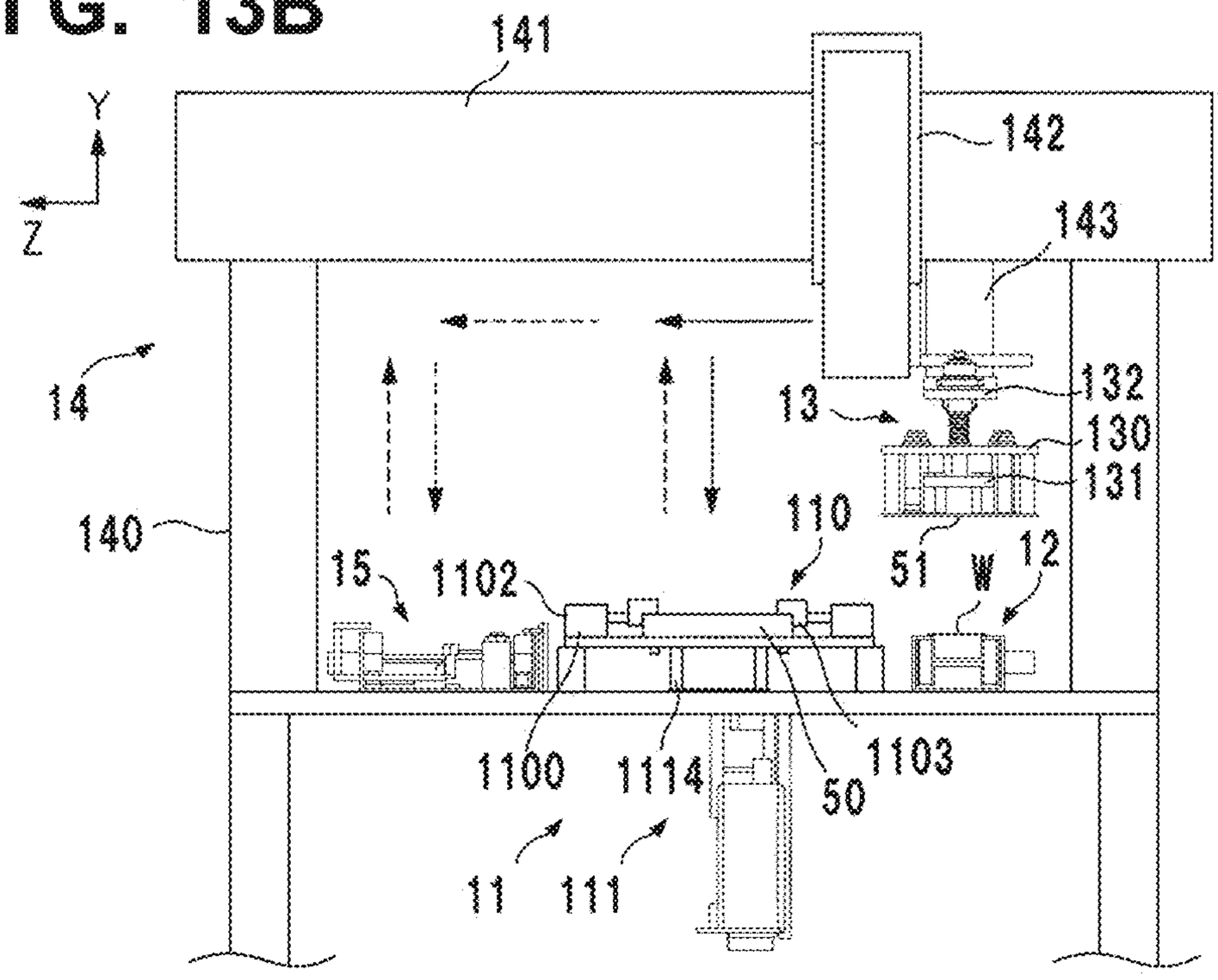

FIG. 14

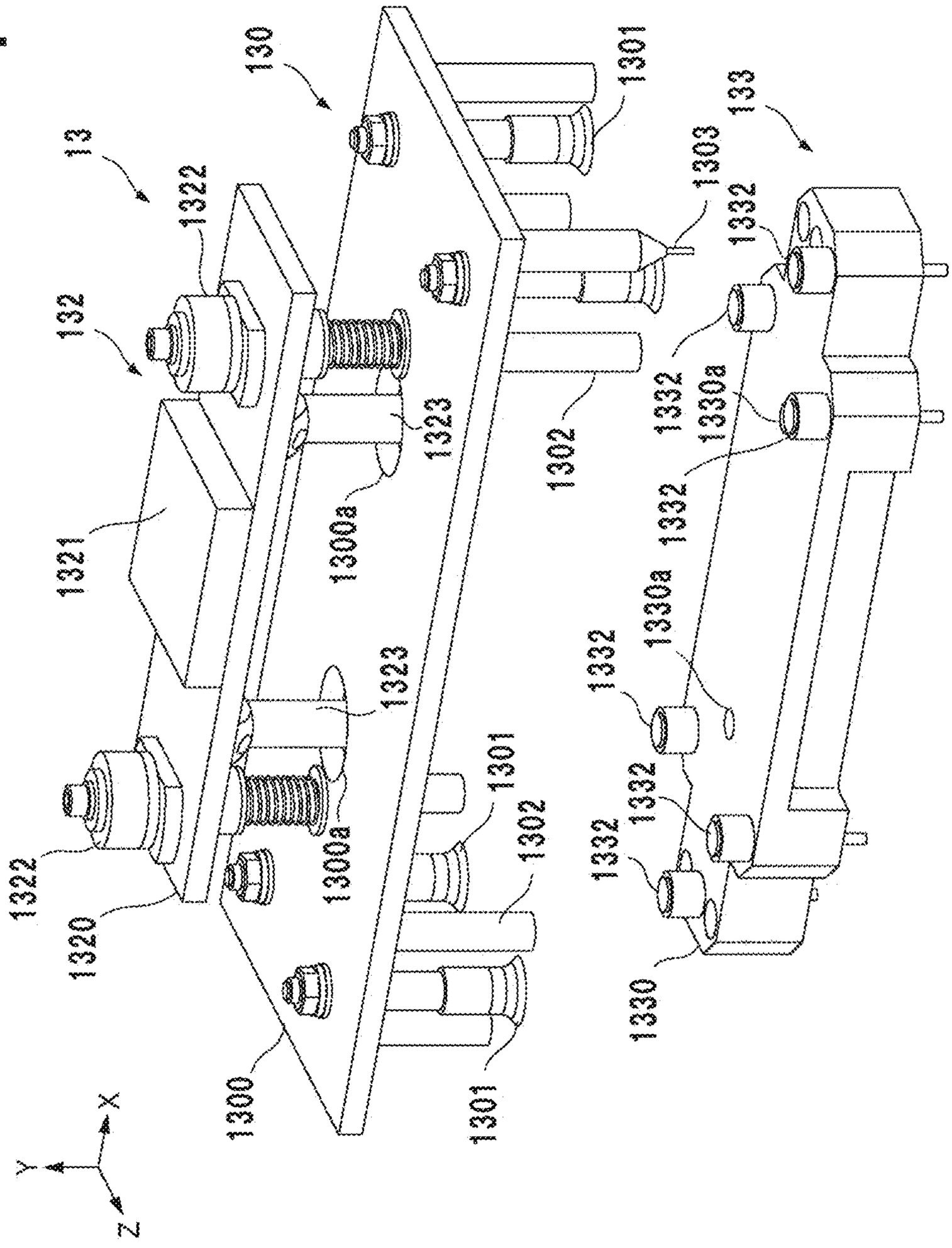
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FIG. 15A

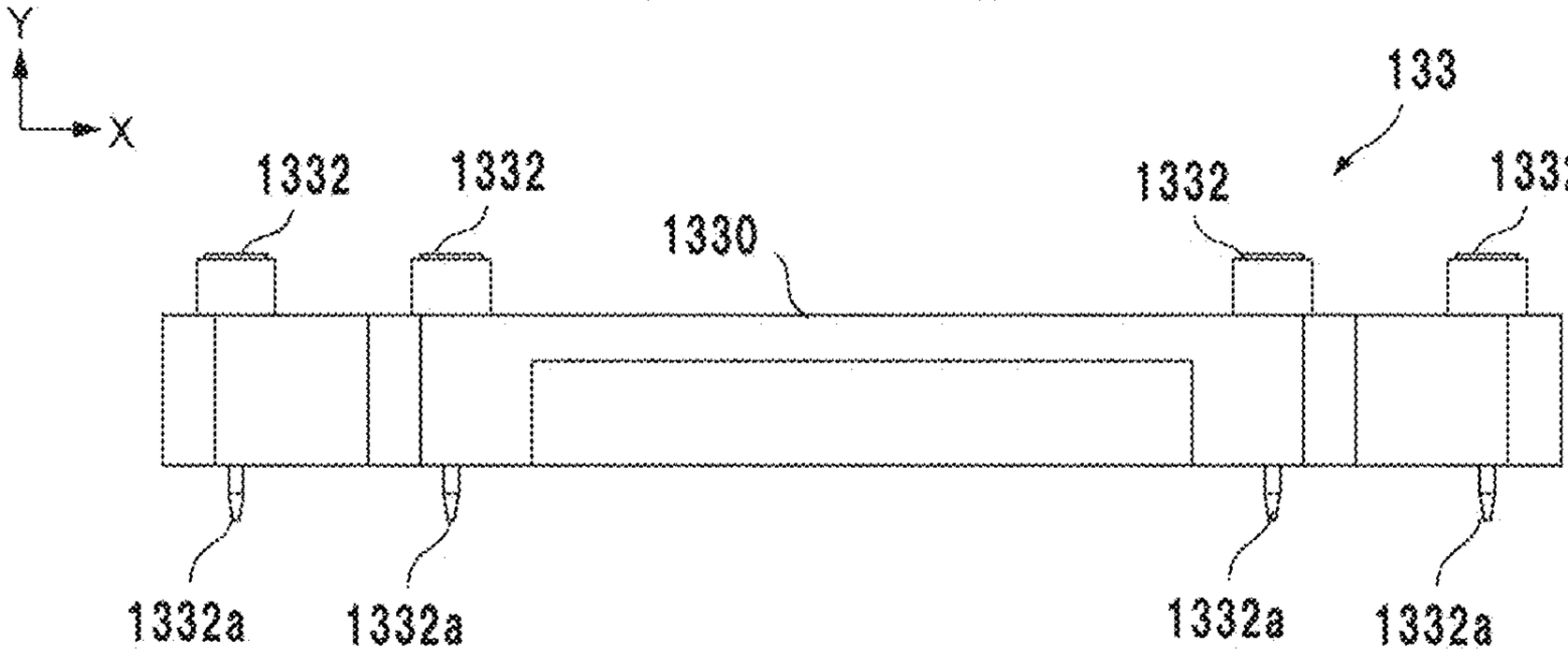


FIG. 15B

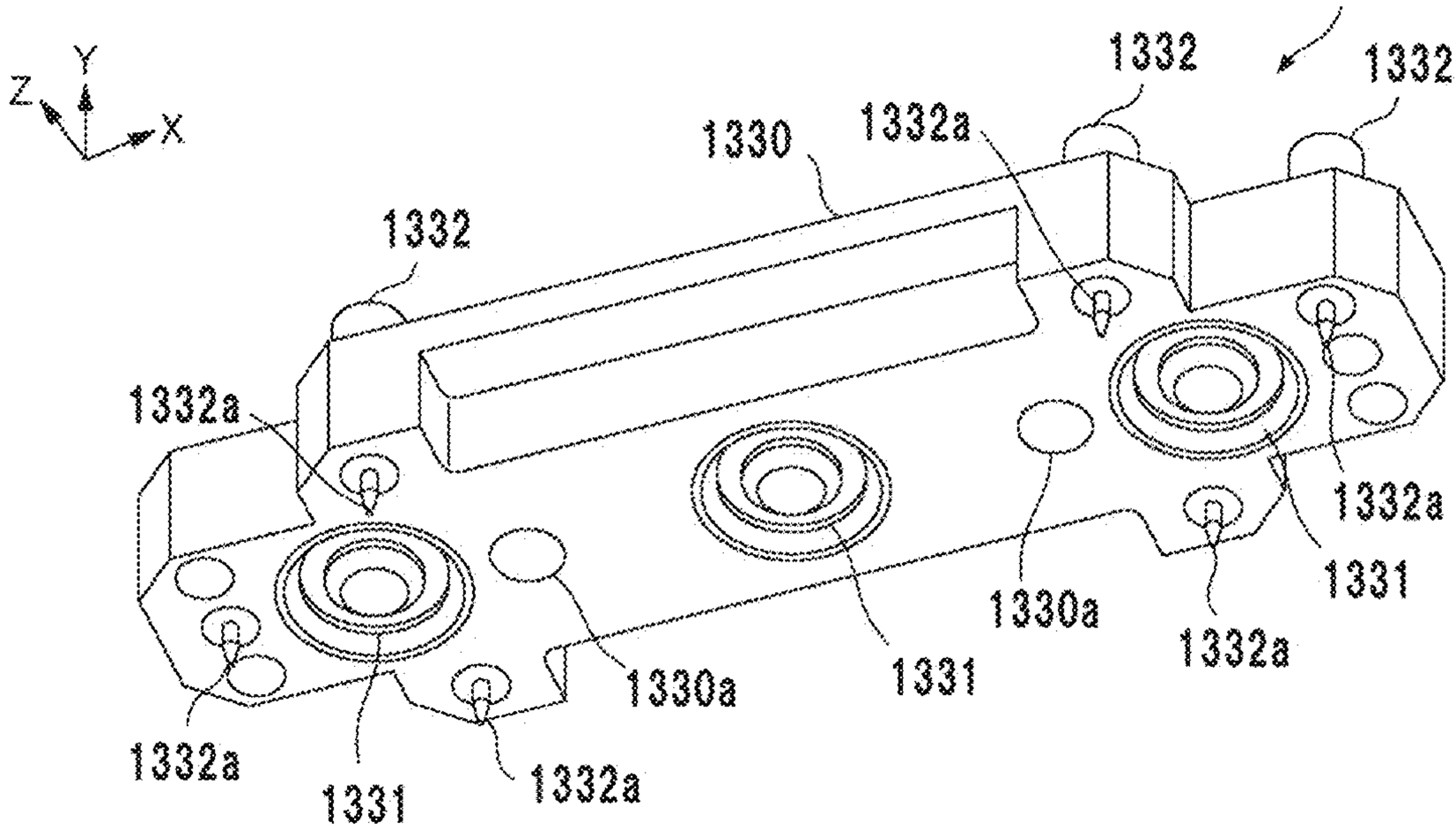


FIG. 16A

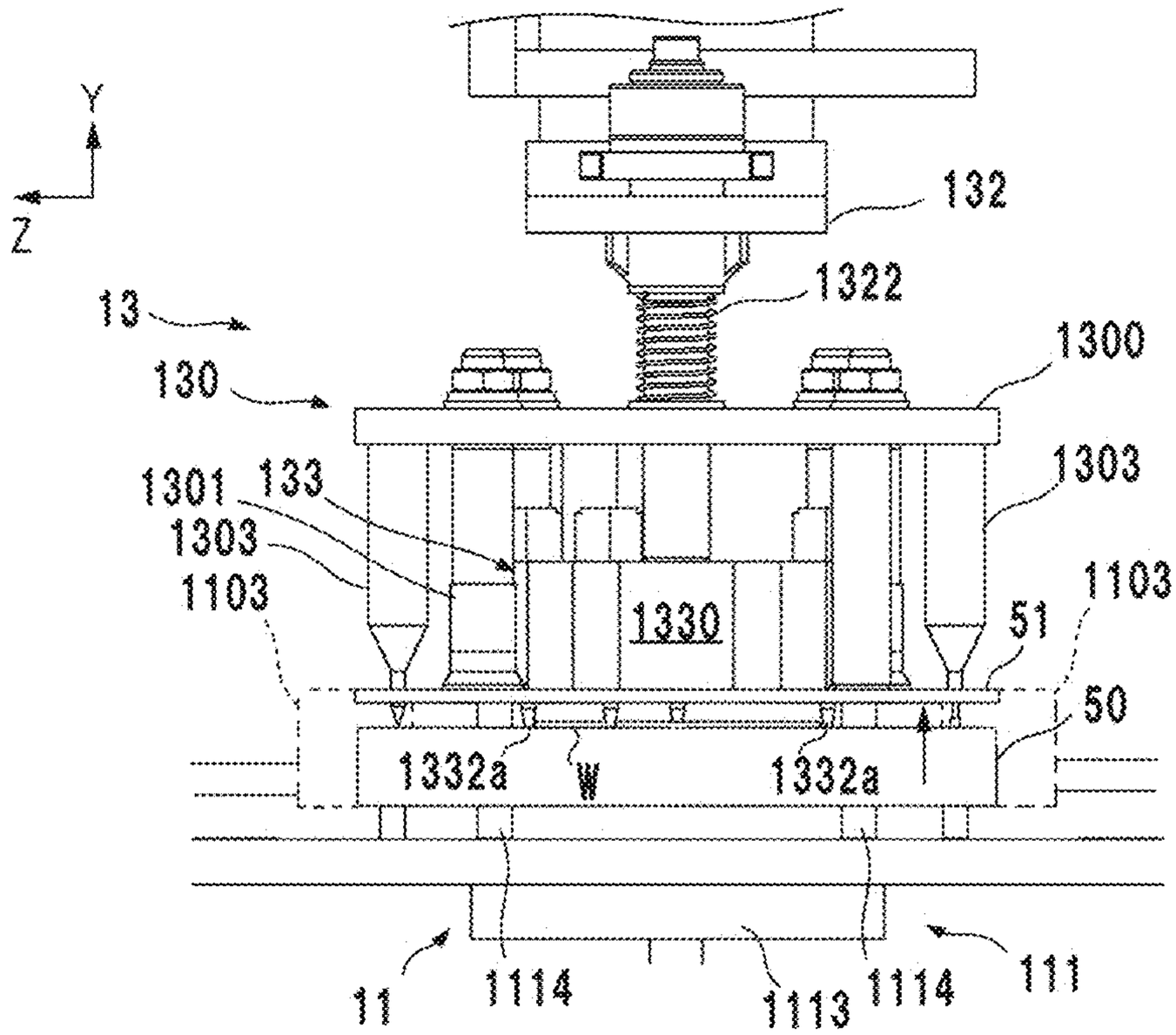


FIG. 16B

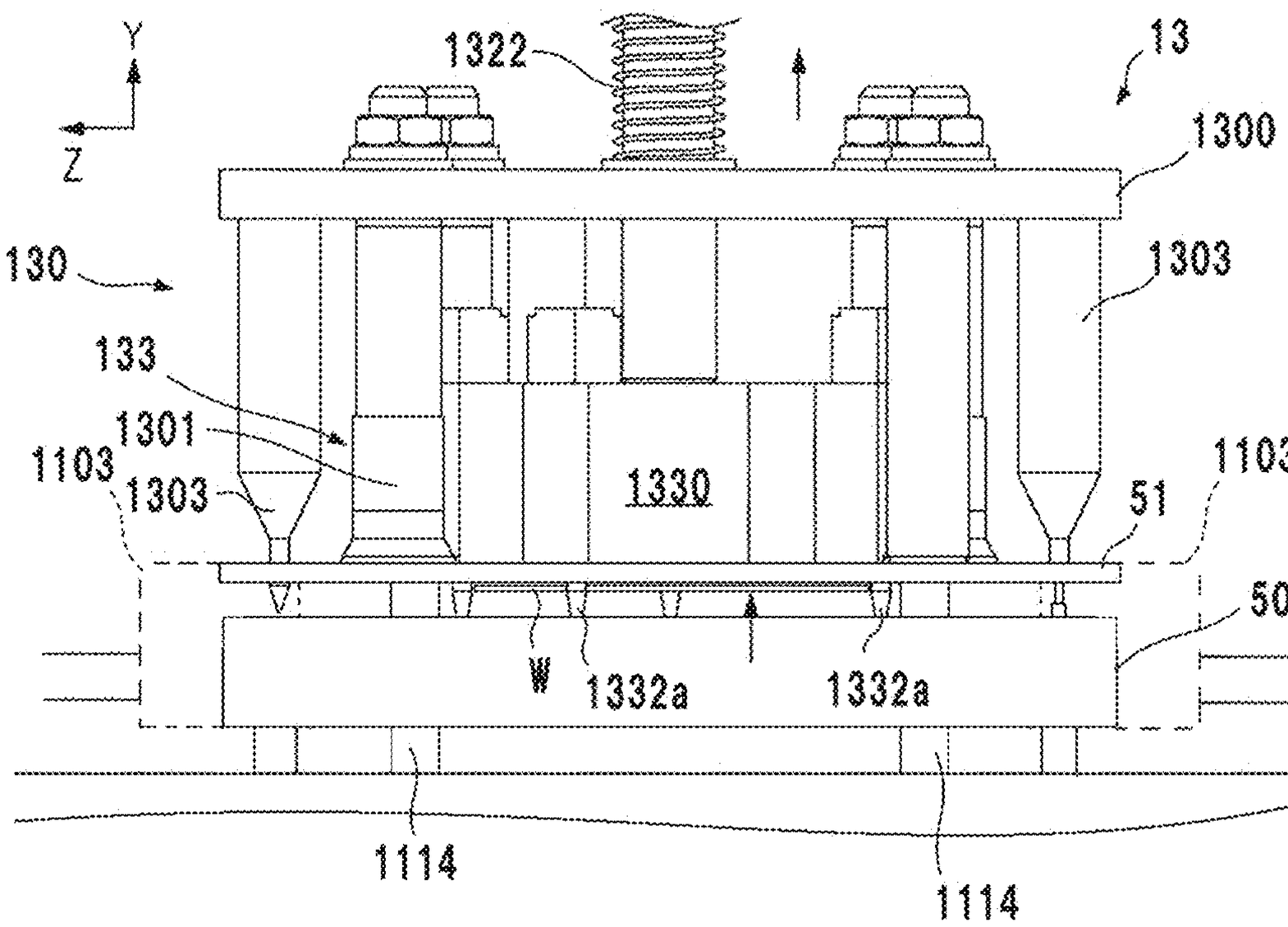


FIG. 17A

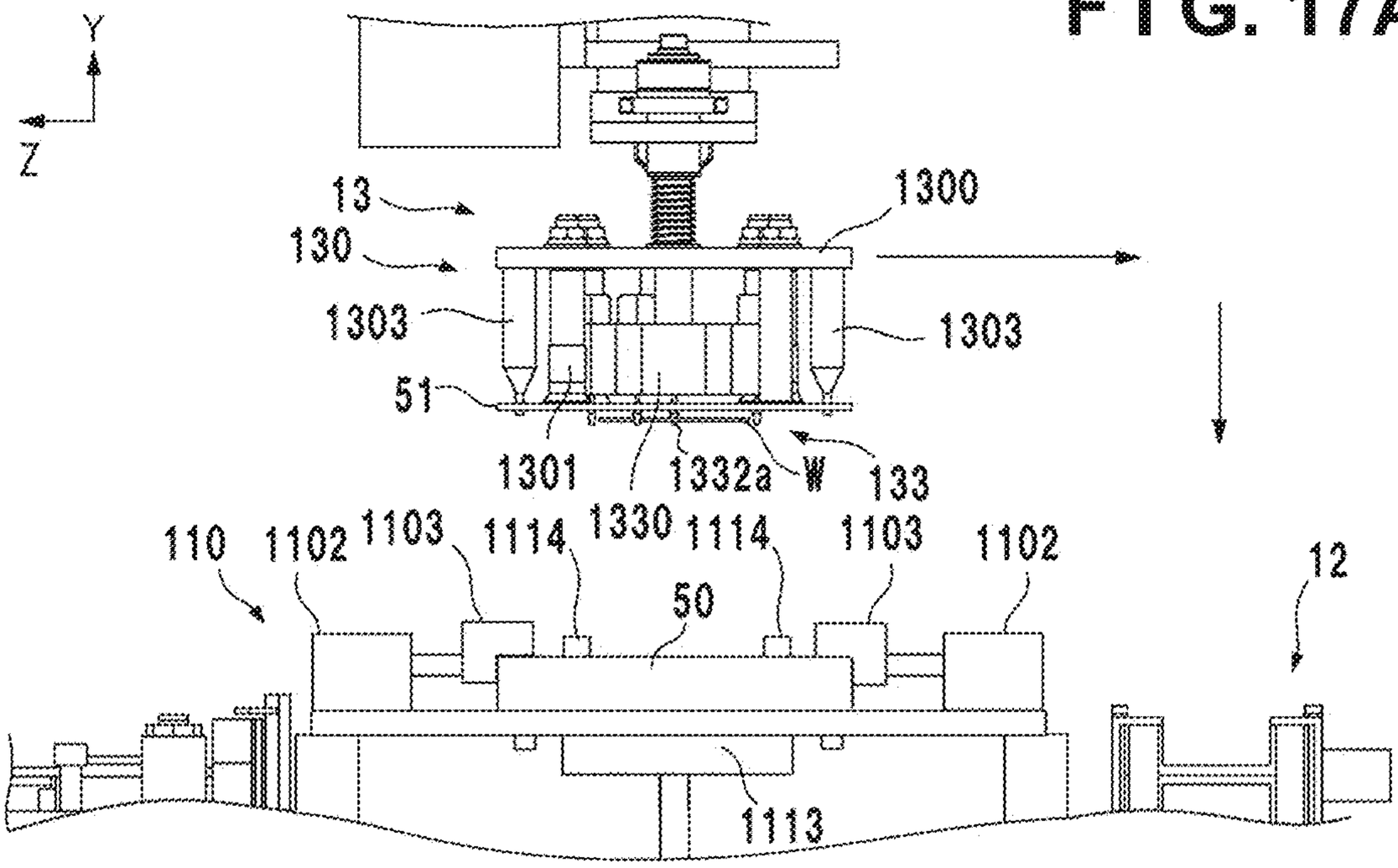
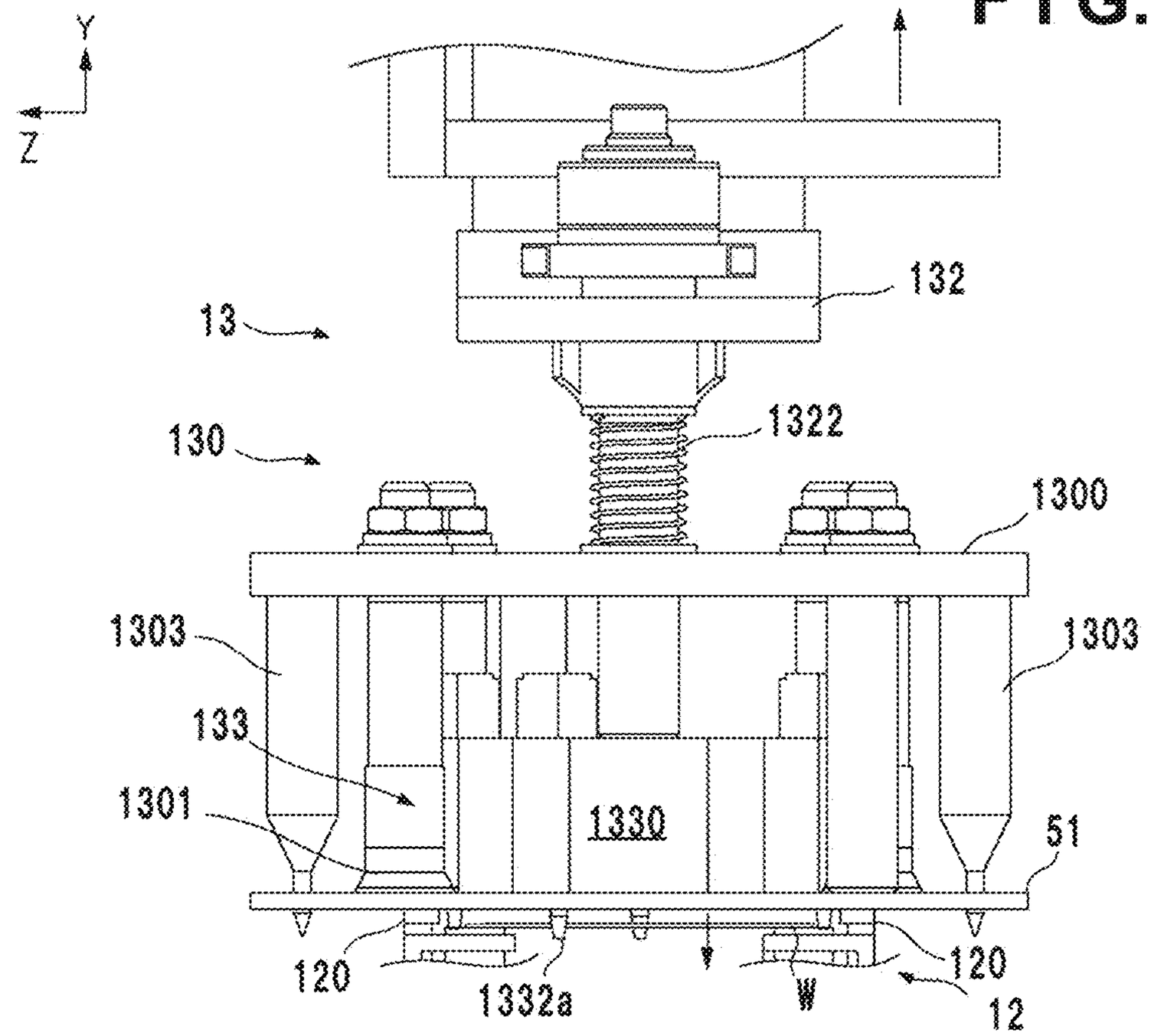


FIG. 17B



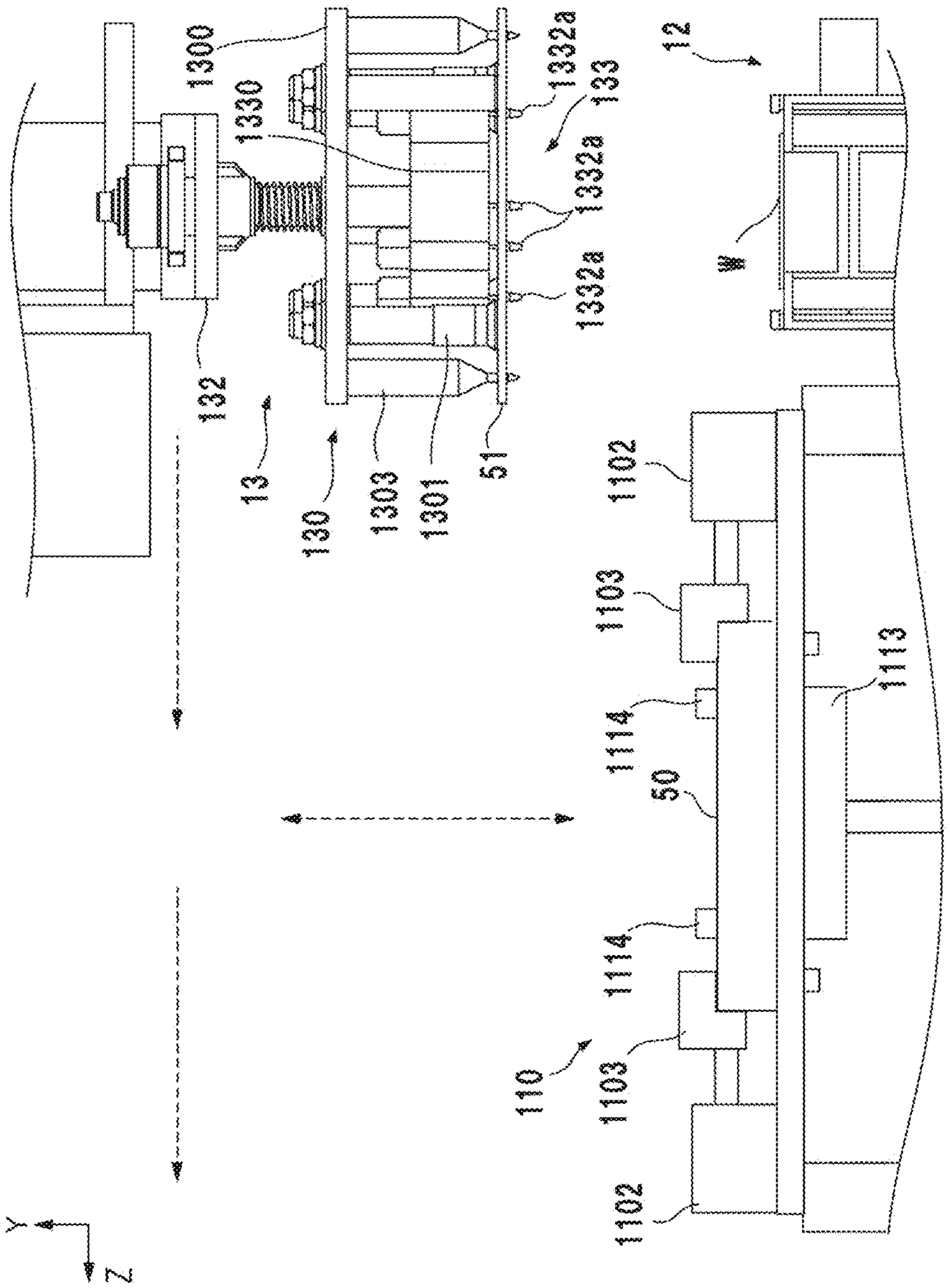

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FIG. 18

TRANSFER METHOD, HOLDING APPARATUS, AND TRANSFER SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a transfer method, a holding apparatus, and a transfer system.

2. Description of the Related Art

When a substrate is transported to a processing apparatus or the like, a relatively thin substrate such as a flexible substrate sometimes warps, and transportation becomes difficult. To solve this, there is proposed a method of transporting a substrate to a transport destination while holding the substrate by a carrier. This requires a mechanism of extracting only a substrate from the carrier and transferring it to a processing apparatus or the like. Japanese Patent Laid-Open No. 2010-272650 discloses an apparatus in which the cover of a substrate is removed and the substrate is pushed up by pins and extracted.

The apparatus in Japanese Patent Laid-Open No. 2010-272650 requires two steps: a step of removing and moving a cover, and a step of extracting and moving a substrate. There is room for improvement of the transfer efficiency of a substrate.

SUMMARY OF THE INVENTION

It is an object of the present invention to improve the transfer efficiency of a substrate.

According to an aspect of the present invention, there is provided a transfer method of transferring, from a carrier including a placing portion on which a substrate is placed and a cover that is superposed on an upper surface of the placing portion in close contact, the substrate held between the placing portion and the cover, comprising: a holding step of holding the substrate and the cover on the placing portion by a holding apparatus; and a moving step of moving the holding apparatus to move the substrate and the cover from the placing portion to a transfer destination, wherein in the holding step, the cover is held by a cover holding unit of the holding apparatus, and the substrate is held by a substrate holding unit of the holding apparatus in parallel postures of the cover and substrate.

According to another aspect of the present invention, there is provided a holding apparatus that holds, from a carrier including a placing portion on which a substrate is placed, and a cover that is superposed on an upper surface of the placing portion in close contact, the substrate held between the placing portion and the cover, and the cover, comprising: a cover holding unit configured to hold the cover; a substrate holding unit configured to hold the substrate; and a support unit configured to support the cover holding unit and the substrate holding unit, wherein the support unit supports the cover holding unit to be able to displace the cover holding unit in directions in which the cover holding unit moves close to and apart from the carrier.

According to still another aspect of the present invention, there is provided a transfer system that transfers, from a carrier including a placing portion on which a substrate is placed, and a cover that is superposed on an upper surface of the placing portion in close contact, the substrate held between the placing portion and the cover, comprising: a positioning unit configured to position and hold the placing portion of the carrier; a separation unit configured to separate the cover from the placing portion of the carrier held by the positioning unit; the holding apparatus; and a moving apparatus configured to move the holding apparatus.

Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view showing a substrate processing facility to which a transfer system according to one embodiment of the present invention is applied;

FIG. **2** is a schematic view showing the transfer system in FIG. **1**;

FIG. **3** is a schematic view showing the carrier processing apparatus of the transfer system in FIG. **1**;

FIGS. **4**A and **4**B are schematic views showing the holding apparatus of the transfer system in FIG. **1**;

FIGS. **5**A and **5**B are schematic views showing a cover holding unit;

FIGS. **6**A and **6**B are schematic views showing a substrate holding unit;

FIG. **7** is a block diagram showing a control unit;

FIGS. **8**A and **8**B are views for explaining the operation of the transfer system in FIG. **1**;

FIGS. **9**A and **9**B are views for explaining the operation of the transfer system in FIG. **1**;

FIGS. **10**A and **10**B are views for explaining the operation of the transfer system in FIG. **1**;

FIGS. **11**A and **11**B are views for explaining the operation of the transfer system in FIG. **1**;

FIG. **12** is a view for explaining the operation of the transfer system in FIG. **1**;

FIGS. **13**A and **13**B are views for explaining the operation of the transfer system in FIG. **1**;

FIG. **14** is a schematic view showing a holding apparatus of another example;

FIGS. **15**A and **15**B are schematic views showing the substrate holding unit of the holding apparatus of the other example;

FIGS. **16**A and **16**B are views for explaining the operation of the holding apparatus of the other example;

FIGS. **17**A and **17**B are views for explaining the operation of the holding apparatus of the other example; and

FIG. **18** is a view for explaining the operation of the holding apparatus of the other example.

DESCRIPTION OF THE EMBODIMENTS

First Embodiment

The first embodiment of the present invention will now be described. In the drawings, an arrow Y indicates the vertical direction, and arrows X and Z indicate horizontal directions perpendicular to each other.

<Substrate Processing Facility>

FIG. **1** is a schematic view showing a substrate processing facility A to which a transfer system **1** according to one embodiment of the present invention is applied. The substrate processing facility A includes the transfer system **1**, a storage apparatus **2**, a processing apparatus **3**, and a processing apparatus **4**.

The storage apparatus **2** can store a plurality of carriers **5** (to be described later). The carrier **5** is a tool for holding a substrate. Examples of the substrate are a flexible film-like substrate typified by an FPC (Flexible Printed Circuit) board, a flexible film, a flexible sheet, and a flexible foil. The storage apparatus **2** can store the carrier **5** that holds a substrate W, or

the empty carrier **5** from which the substrate W has been extracted. The storage apparatus **2** is an apparatus which supplies the carrier **5** to the transfer system **1**, and recovers the carrier **5** from the transfer system **1**.

The processing apparatus **3** is an apparatus that performs, for example, heat treatment (reflow) of applied solder. The processing apparatus **4** is, for example, an apparatus that performs cooling and cleaning processing. The transfer system **1** includes a transport apparatus **10** for loading the carrier **5** holding the substrate W from the processing apparatus **3**. The transport apparatus **10** extracts the substrate W from the carrier **5**, and transports the extracted substrate to the processing apparatus **4**. The empty carrier **5** from which the substrate W has been extracted is transported to the storage apparatus **2**.

<Transfer System>

FIG. **2** is a schematic view showing the transfer system **1**. The transfer system **1** includes the transport apparatus **10**, a carrier processing apparatus **11**, a transport apparatus **12**, a holding apparatus **13**, and a moving apparatus **14**. The support structure and arrangement of the transport apparatus **10**, carrier processing apparatus **11**, transport apparatus **12**, and moving apparatus **14** are not particularly limited. In this embodiment, the transport apparatus **10**, the carrier processing apparatus **11**, the transport apparatus **12**, and the moving apparatus **14** are arranged on a frame having a base portion. The transport apparatuses **10** and **12** are arranged so that their transport directions become parallel to each other and the transport apparatuses **10** and **12** are spaced apart from each other in a direction perpendicular to the transport direction. The carrier processing apparatus **11** is interposed between the transport apparatuses **10** and **12**. The moving apparatus **14** is arranged to be able to move the holding apparatus **13** between the transport apparatus **10**, the carrier processing apparatus **11**, and the transport apparatus **12**.

The transport apparatus **10** includes, for example, a belt conveyor mechanism extending in the X direction serving as the transport direction. The transport apparatus **10** transports the carrier **5** placed on a belt (not shown) while keeping the horizontal posture of the carrier **5**. The example in FIG. **2** shows a state in which the carrier **5** is mounted on the transport apparatus **10**. The transport apparatus **10** loads the carrier **5** from the processing apparatus **3** and unloads the carrier **5** to the storage apparatus **2**. The carrier **5** from the processing apparatus **3** holds the substrate W. The empty carrier **5** from which the substrate W has been extracted is unloaded to the storage apparatus **2**.

The carrier **5** includes a placing portion **50** at which the substrate W is placed, and a cover **51** that is superposed on the upper surface of the placing portion **50** in close contact. Both the placing portion **50** and the cover **51** are plate-like members, and have a square shape in this embodiment. The placing portion **50** and the cover **51** attract (are coupled to) each other by magnetic force. In this case, for example, it is possible to arrange a permanent magnet at the placing portion **50**, and make the cover **51** of a metal material that is attracted to the magnet. As for close contact/coupling between the placing portion **50** and the cover **51**, they may be physically pinched by a clamp member or the like, in addition to attraction by magnetic force.

The substrate W is sandwiched and held between the placing portion **50** and the cover **51**. The cover **51** includes a plurality of notches **51***a*, an opening **51***b*, and positioning holes **51***c*. The notches **51***a* are formed near the four corners of the cover **51**. The notches **51***a* are formed to prevent interference with the cover **51** when the carrier processing apparatus **11** (to be described later) holds the placing portion **50**. The opening **51***b* forms an exposure portion at which the substrate W and the cover **51** do not overlap each other. In this embodiment, the opening **51***b* is formed at the center of the cover **51**, but the position of the opening **51***b* is arbitrary. Also, the opening **51***b* may be replaced with a notch. Further, the size of the cover **51** may be designed to be smaller than that of the substrate W so that the substrate W is exposed outside the periphery of the cover **51**. The holes **51***c* are through holes formed at the four corners of the cover **51**. At the four corners of the placing portion **50**, holes **50***a* are formed at positions where they overlap the holes **51***c* (see FIG. **3**).

The transport apparatus **12** unloads the substrate W to the processing apparatus **4**. The transport apparatus **12** includes, for example, a belt conveyor mechanism extending in the X direction. The transport apparatus **12** transports the substrate W directly placed on a belt (not shown) while keeping the horizontal posture of the substrate W.

The carrier processing apparatus **11** is interposed between the transport apparatuses **10** and **12**. The carrier processing apparatus **11** will be explained with reference to FIGS. **2** and **3**. FIG. **3** is a schematic view showing the carrier processing apparatus **11**. The carrier processing apparatus **11** includes a positioning unit **110** and a separation unit **111**. FIG. **3** shows a state in which the positioning unit **110** holds the placing portion **50**.

The positioning unit **110** is a unit that positions and holds the carrier **5**. In this embodiment, the positioning unit **110** grips and positions the placing portion **50**. The positioning unit **110** includes a base member **1100**, a plurality of placing pins **1101**, a plurality of actuators **1102**, and a plurality of positioning members **1103**.

The base member **1100** is a plate-like member and supports the above-described components. An opening through which a pin support table **1113** and abutment members **1114** of the separation unit **111** (to be described later) can pass is formed at the center of the base member **1100**. The abutment member **1114** is a pin in this embodiment. In some cases, the abutment member **1114** will be called the pin **1114**.

Each placing pin **1101** stands on the base member **1100**, and includes a guide portion **1101***a* having a distal end portion formed into a conical shape, and a support surface **1101***b* that supports the lower surface of the placing portion **50**. In this embodiment, the placing pins **1101** are arranged at two portions. Holes in which the placing pins **1101** are fitted with play are formed in the lower surface of the placing portion **50**. While the placing portion **50** is guided, it is supported and mounted on the support surfaces of the placing pins **1101**.

Each actuator **1102** is, for example, an electric cylinder, and reciprocates the corresponding positioning member **1103** in the Z direction. In this embodiment, one actuator **1102** is assigned to one positioning member **1103**.

Each positioning member **1103** has an L shape constituted by a vertical portion and a horizontal portion. The positioning member **1103** abuts against the periphery of the placing portion **50** from the upper and side portions, and positions and holds the placing portion **50**. In this embodiment, two positioning members **1103** are assigned to each of two facing sides of the placing portion **50**. By driving of each actuator **1102**, the vertical and horizontal portions of the positioning members **1103** abut against the two facing sides of the placing portion **50** to sandwich and position the placing portion **50** and hold it in the horizontal posture.

The separation unit **111** is a unit that separates, from the placing portion **50**, the cover **51** chucked to the placing portion **50**. The separation unit **111** includes a driving unit **1110**, an elevating member **1111**, a guide portion **1112**, the pin support table **1113**, and the plurality of pins **1114**. The driving unit **1110** includes a driving source **1110***a* such as a motor,

and a transmission mechanism **1110***b* that transmits the driving force of the driving source **1110***a* to the elevating member **1111**. The transmission mechanism **1110***b* is, for example, a ball screw mechanism, and moves up and down the elevating member **1111** by the driving force of the driving source **1110***a*. The guide portion **1112** guides up/down movement of the elevating member **1111**. In this embodiment, the guide portion **1112** includes a rail **1112***a* extending in the Y direction serving as the up/down movement direction. A slider **1111***a* coupled to the elevating member **1111** is engaged with the rail **1112***a*.

The pin support table **1113** is a plate-like member that is coupled to the elevating member **1111** and moves up and down together with the elevating member **1111**. The plurality of pins **1114** each have a support-portion-side distal end formed into a horizontal surface, and stand on the pin support table **1113**. Through holes or notches capable of receiving the pins **1114** are formed in the placing portion **50**. Along with up/down movement of the pin support table **1113**, each pin **1114** can move between a working position (position in FIG. **3**) set at an upper position, and a retreat position set at a position below the placing portion **50**. At the working position, the pin **1114** projects from the upper surface of the placing portion **50**.

When separating the cover **51** from the placing portion **50** held by the positioning unit **110**, the pins **1114** are moved up from the retreat positions to the working positions, abut against the lower surface of the cover **51**, and push up the cover **51**. Accordingly, the cover **51** is separated from the placing portion **50** and lifted above the placing portion **50**.

The moving apparatus **14** will be explained with reference to FIG. **2**. The moving apparatus **14** can move the holding apparatus **13** in the Y and Z directions. The moving apparatus **14** moves the holding apparatus **13** vertically and horizontally between the transport apparatus **10** and the carrier processing apparatus **11**, and between the carrier processing apparatus **11** and the transport apparatus **12**.

The moving apparatus **14** includes a pair of columns **140** that are spaced apart from each other in the Z direction serving as the transport direction and extend in the Y direction, a guide unit **141** installed across the pair of columns **140**, a horizontally moving member **141***a* supported to be movable in the Z direction along the guide unit **141**, an elevating unit **142** attached to the horizontally moving member **141***a*, an elevating member **144** that is moved up and down by the elevating unit **142**, and a pivot unit **143** attached to the elevating member **144**. The elevating member **144** supports the pivot unit **143**. The pivot unit **143** is connected to the holding apparatus **13**, and pivots the substrate W and cover **51** held by the holding apparatus **13** in a state in which the surfaces of the substrate W and cover **51** are parallel to the X-Z plane (horizontal plane), thereby adjusting the angle of the held substrate W or cover **51** on the X-Z plane. A mechanism of moving the elevating unit **142** by the guide unit **141**, and a mechanism of moving up and down the elevating member **144** by the elevating unit **142** can be well-known mechanisms. Such a mechanism can be constituted by, for example, a driving source such as a motor, and a transmission mechanism (for example, a belt transmission mechanism, ball screw mechanism, or rack and pinion mechanism) that transmits the driving force of the driving source. When sensors such as encoders that detect the positions of the horizontally moving member **141***a* and elevating member **144** are arranged on the guide unit **141** and the elevating unit **142**, movement control of the holding apparatus **13** can be performed based on the detection results of the respective sensors. This embodiment employs a traverse mechanism that linearly moves the holding apparatus **13**. Alternatively, the holding apparatus **13** may be mounted at the distal end of each of various moving mechanisms such as a vertically articulated robot.

The holding apparatus **13** will be explained with reference to FIGS. **4**A to **6**B. FIGS. **4**A and **4**B are schematic views showing the holding apparatus **13**. FIG. **4**A is a perspective view showing the holding apparatus **13**, and FIG. **4**B is an exploded perspective view showing the holding apparatus **13**. FIGS. **5**A and **5**B are schematic views showing a cover holding unit **130**. FIGS. **6**A and **6**B are schematic views showing a substrate holding unit **131**.

The holding apparatus **13** includes the cover holding unit **130**, the substrate holding unit **131**, and a support unit **132** that supports them.

The cover holding unit **130** is a unit that holds the cover **51** of the carrier **5** to freely cancel holding. The cover holding unit **130** includes a base member **1300**, chucking portions **1301**, cover regulating members **1302**, and positioning members **1303**.

The base member **1300** is a plate-like member, and has openings **1300***a* (two openings **1300***a* are illustrated in this embodiment) through which support portions **1323** of the support unit **132** (to be described later) are inserted. The openings **1300***a* are formed in correspondence with the support portions **1323**, and the number of openings **1300***a* may be one or three or more.

Each chucking portion **1301** chucks the cover **51**. The chucking portion **1301** is supported by the base member **1300** so as to project below the base member **1300**. A chucking pad that sucks air is attached to the distal end portion of the chucking portion **1301**. By sucking air by a pump (not shown) through the suction pores of the chucking pad, the cover **51** can be sucked at a negative pressure and held. By stopping the suction and releasing the cover **51** to the atmospheric pressure, the holding of the cover **51** is canceled. In this embodiment, four chucking portions **1301** are arranged. The chucking portions **1301** chuck four portions of the upper surface of the cover **51**, and hold the cover **51** in the horizontal posture together with the cover regulating members **1302**.

Each cover regulating member **1302** is a member that regulates the holding position (holding height) of the cover **51** on the cover holding unit **130**. The cover regulating member **1302** can stably hold the posture of the cover **51**. The cover regulating member **1302** is supported by the base member **1300** so as to project below the base member **1300**. The cover regulating member **1302** has a horizontal positioning surface at its distal end portion. The upper surface of the cover **51** abuts against the positioning surface at the time of chucking the cover **51**, and the cover regulating member **1302** regulates the position of the cover **51** in the chucking direction (Y direction) to hold the horizontal posture of the cover **51**. In this embodiment, four cover regulating members **1302** are arranged. The cover regulating members **1302** abut against four portions of the upper surface of the cover **51**, and regulate the position of the cover **51** in the chucking direction.

Each positioning member **1303** is a member that positions the cover holding unit **130** with respect to the carrier **5**. The positioning member **1303** is supported by the base member **1300** so as to project below the base member **1300**. A pin is attached to the distal end portion of the positioning member **1303**. By inserting this pin into the hole **50***a* of the placing portion **50** and the hole **51***c* of the cover **51** and engaging it with the holes at the time of down movement, relative positioning of the positioning member **1303** and carrier **5** in the horizontal direction can be performed. In this embodiment, two positioning members **1303** are arranged. The positioning

members **1303** are engaged with the placing portion **50** at two portions (more specifically, two portions diagonally), and regulate the relative position.

The substrate holding unit **131** is a unit that holds the substrate W to freely cancel holding. The substrate holding unit **131** includes a base member **1310**, chucking portions **1311**, and substrate regulating members **1312**. The base member **1310** is a plate-like member. Attaching holes **1310***a* (two attaching holes **1310***a* are illustrated in this embodiment) in which the support portions **1323** of the support unit **132** (to be described later) are fixed are formed in the base member **1310**.

Each chucking portion **1311** chucks the substrate W. The chucking portion **1311** is supported by the base member **1300** so as to project below the base member **1300**. A bellows pad that sucks air is attached to the distal end portion of the chucking portion **1311**. By sucking air by a pump (not shown) through the suction pores of the bellows pad, the substrate W can be sucked at a negative pressure and held. By stopping the suction and releasing the substrate W to the atmospheric pressure, the holding of the substrate W is canceled. In this embodiment, eight chucking portions **1311** are arranged. The chucking portions **1311** chuck the upper surface of the substrate W at eight portions, and hold the substrate W in the horizontal posture together with the substrate regulating members **1312**. The chucking portions **1311** are arranged at positions where they do not interfere with the substrate regulating members **1312** (to be described later), and near the substrate regulating members **1312**. The chucking portions **1311** are arranged to sandwich each substrate regulating member **1312**. The chucking portions **1311** hold the substrate W while reliably making the upper surface of the substrate W abut against positioning portions **1312***b* (to be described later).

Each substrate regulating member **1312** is a member that regulates the holding position of the substrate W in the substrate holding unit **131**. The substrate regulating member **1312** is supported by the base member **1310** so as to project below the base member **1310**. The distal end portion of the substrate regulating member **1312** has a horizontal attaching portion **1312***a*, and a positioning portion **1312***b* formed to project from the attaching portion **1312***a*. The attaching portion **1312***a* is used at the time of attachment to the base member **1310** by a fastening member such as a bolt. At the time of chucking the substrate W, part of the upper surface of the substrate W abuts against the lower surface of the positioning portion **1312***b* to regulate the position of the substrate W in the chucking direction (Y direction). In this embodiment, six substrate regulating members **1312** are arranged on the lower side of the base member **1310**, and the lower surfaces of the respective positioning portions **1312***b* are arranged on the same horizontal plane (flush with each other). Sets each of three substrate regulating members **1312** are linearly aligned in two arrays. The positioning portions **1312***b* forming each array are linearly arranged, and the respective arrays are arranged line-symmetrically with respect to the center line of the base member **1310**. By arranging the plurality of positioning portions **1312***b*, the flexion of the substrate W at the time of chucking can be prevented, and the substrate W can be held in the horizontal posture. In some cases, even one positioning portion **1312***b* can hold the substrate W in the horizontal posture when the lower surface of the positioning portion **1312***b* has a large area.

The support unit **132** is a unit that supports the cover holding unit **130** and the substrate holding unit **131**, and is connected to the pivot unit **143** of the moving apparatus **14**.

The support unit **132** includes a base member **1320**, support portions **1322**, and the support portions **1323**. The base member **1320** is a plate-like member. A connecting member **1321** to which the pivot unit **143** (in particular, its rotation output portion) is connected is arranged at the center portion of the upper surface of the base member **1320**. A bolt hole or the like through which the connecting member **1321** is fastened to, for example, the pivot unit **143** is formed in the connecting member **1321**.

Each support portion **1322** has one end side connected to the base member **1320**, and the other end side connected to the base member **1300** of the cover holding unit **130**. The support portion **1322** supports the cover holding unit **130**. In this embodiment, two support portions **1322** are arranged apart from each other in the X direction. In this embodiment, the cover holding unit **130** is supported (suspended) to be displaceable in directions in which it moves close to and apart from the carrier **5**. Since the plurality of support portions **1322** are arranged, the cover holding unit **130** is supported not only to be displaceable in the directions in which it moves close to and apart from the carrier **5**, but also to be inclinable with respect to the horizontal plane.

In this embodiment, the support portion **1322** is constituted as a floating mechanism that floatingly supports the cover holding unit **130**. The support portion **1322** can displace the cover holding unit **130**.

More specifically, the support portion **1322** is constituted by a rod cylinder and a spring. The cylinder portion of the rod cylinder is fixed to the base member **1320**, and the rod portion is fixed to the base member **1300**. The spring is interposed between the cylinder portion and the base member **1300** to surround the rod portion. By the projection/retraction amount of the rod portion with respect to the cylinder portion, the base member **1300** can be displaced in a direction (Y direction) in which the base member **1300** moves close to or apart from the base member **1320**. As a result, when holding the cover **51**, the cover holding unit **130** can be displaced with respect to the support unit **132** in the direction in which it moves close to or apart from the carrier **5**. The spring biases the base members **1300** and **1320** in directions in which they move apart from each other.

Each support portion **1323** has one end side connected to the base member **1320**, and the other end side connected to the base member **1310** through the opening **1300***a* formed in the base member **1300**. The support portion **1323** supports (suspends) the substrate holding unit **131**. In this embodiment, two support portions **1323** are arranged apart from each other in the X direction. The support portion **1323** is a column-like member, and the base member **1310** is fixed to the distal end portion of the support portion **1323**. Unlike the cover holding unit **130**, the substrate holding unit **131** is supported not to be displaced with respect to the support unit **132**. Both the base members **1310** and **1320** are maintained in the horizontal posture. The base member **1300** is basically maintained in the horizontal posture though it is slightly inclined owing to the contraction/extension of the support portions **1322**.

<Control Unit>

FIG. **7** is a block diagram showing a control unit **6** of the transfer system **1**. The control unit **6** controls the overall transfer system **1**.

The control unit **6** includes a processing unit **61** such as a CPU, a storage unit **62** such as a RAM or ROM, and an interface unit **63** that interfaces an external device and the processing unit **61**. The interface unit **63** includes a communication interface that communicates with a host computer, in

addition to an I/O interface. The host computer is, for example, a computer that controls the overall substrate processing facility A.

The processing unit **61** executes a program stored in the storage unit **62**, and controls the detection results of various sensors **65**, and various actuators **64**. The sensors **65** include, for example, a sensor that detects the position of the elevating member **144**. The actuators **64** include, for example, the driving sources of the transport apparatus **10**, carrier processing apparatus **11**, transport apparatus **12**, and moving apparatus **14**, and a pump and control valve for performing negative-pressure suction in the holding apparatus **13**.

<Control Example>

A control example of the transfer system **1** will be described with reference to FIGS. **8**A to **13**B. An operation of transferring the substrate W will be explained here. More specifically, an example in which the substrate W is extracted from the carrier **5** that holds the substrate W and has been loaded onto the transport apparatus **10**, and the substrate W is transferred to a transfer destination will be described. In this example, the transfer destination of the substrate W is the transport apparatus **12**.

FIG. **8**A shows a state in which the carrier **5** that holds the substrate W and has been supplied from the processing apparatus **3** is loaded to a predetermined position on the transport apparatus **10**. First, as shown in FIG. **8**A, the moving apparatus **14** moves the holding apparatus **13** to above the carrier **5**. The pivot unit **143** adjusts the rotation angle of the holding apparatus **13** on the horizontal plane. Then, as shown in FIG. **8**B, the moving apparatus **14** moves down the holding apparatus **13**, and the holding apparatus **13** holds the carrier **5**. At this time, the positioning members **1303** of the cover holding unit **130** are inserted in and engaged with the holes **50***a* of the placing portion **50** and the holes **51***c* of the cover **51** during the down movement of the holding apparatus **13**. As a result, horizontal positioning of the holding apparatus **13** and carrier **5** is performed. Subsequently, suction of the chucking portions **1301** of the cover holding unit **130** starts to chuck and hold the cover **51**. At this time, the cover regulating members **1302** regulate the holding position. Since the cover **51** and the placing portion **50** are coupled by magnetic force, the holding apparatus **13** holds the overall carrier **5** including the substrate W by chucking and holding the cover **51**.

Then, as shown in FIG. **9**A, the moving apparatus **14** moves the holding apparatus **13** holding the carrier **5** to above the carrier processing apparatus **11**. The pivot unit **143** adjusts the rotation angle of the holding apparatus **13** on the horizontal plane. Subsequently, as shown in FIG. **9**B, the moving apparatus **14** moves down the holding apparatus **13** to place the carrier **5** on the placing pins **1101** of the positioning unit **110**. Further, the actuators **1102** are driven to make the positioning members **1103** abut against the placing portion **50**, and position and hold the placing portion **50**. Since the notches **51***a* are formed in the cover **51**, the cover **51** and the positioning members **1103** do not interfere with each other when the positioning members **1103** abut against the placing portion **50**.

Then, as shown in FIG. **10**A, the driving unit **1110** of the separation unit **111** is driven to move up the pin support table **1113**. As shown in FIG. **10**B, the pins **1114** project from the placing portion **50** to push up the cover **51** and separate the cover **51** upward from the placing portion **50**. That is, the coupling between the placing portion **50** and the cover **51** is canceled, and the cover **51** is located at a position spaced apart from the placing portion **50** by a predetermined distance. The cover holding unit **130** is supported by the support portions **1322** to be displaceable with respect to the support unit **132**. Thus, when the cover **51** is pushed up, the cover holding unit **130** also moves up together with the cover **51**.

Thereafter, suction of the chucking portions **1311** of the substrate holding unit **131** starts. Since the opening **51***b* is formed in the cover **51**, a portion of the substrate W that does not overlap the cover **51** is chucked and held by the chucking portions **1311** via the opening **51***b*. At this time, the substrate regulating members **1312** regulate the position of the substrate W. The cover holding unit **130** chucks and holds the cover **51**, and the substrate holding unit **131** chucks and holds the substrate W. In this embodiment, chucking of the substrate W starts after canceling the coupling between the cover **51** and the placing portion **50**. However, chucking of the substrate W may start before canceling the coupling between the cover **51** and the placing portion **50**.

Subsequently, as shown in FIG. **11**A, the moving apparatus **14** moves up the holding apparatus **13**. At this time, the placing portion **50** stays on the carrier processing apparatus **11**, and the cover **51** and the substrate W move up together with the holding apparatus **13**. Both the cover **51** and the substrate W are held parallel to each other in the horizontal posture.

By pushing up the cover **51** by the pins **1114**, the cover holding unit **130** that has been displaced upward with respect to the support unit **132** returns (moves down) to the original position by this displacement.

Then, as shown in FIG. **11**B, the moving apparatus **14** moves, to above the transport apparatus **12**, the holding apparatus **13** holding the cover **51** and the substrate W. The pivot unit **143** adjusts the rotation angle of the holding apparatus **13** on the horizontal plane. As shown in FIG. **12**, the holding apparatus **13** is moved down onto the transport apparatus **12**.

At upper portions of the transport apparatus **12**, projections **120** are formed at positions where they do not interfere with the substrate W, as shown in FIG. **13**A. When the holding apparatus **13** is moved down onto the transport apparatus **12**, the projections **120** abut against the cover **51** and stop the down movement of the cover **51** prior to the substrate W. More specifically, when the projections **120** abut against the lower surface of the cover **51**, the cover holding unit **130** cannot move down anymore. The support portions **1322** support the cover holding unit **130** so that the cover holding unit **130** can be displaced with respect to the support unit **132**. Hence, if the down movement of the holding apparatus **13** continues, the substrate holding unit **131** moves down to be lower than the cover holding unit **130**, and the substrate W moves apart from the cover **51**.

The down movement of the holding apparatus **13** is stopped at a predetermined position, and the suction of the chucking portions **1311** is stopped to release the substrate W to the atmospheric pressure. Thus, the chucking of the substrate W is canceled and the substrate W is placed on the transport apparatus **12**. By these operations, the transfer of the substrate W to the transport apparatus **12** is completed.

After that, an operation of superposing the cover **51** on the placing portion **50** on the positioning unit **110** at the transfer source to empty the carrier **5**, and transferring the empty carrier **5** to the transport apparatus **10** is performed. First, as shown in FIG. **13**B, the holding apparatus **13** holding only the cover **51** is moved above the carrier processing apparatus **11**. The pivot unit **143** adjusts the rotation angle of the holding apparatus **13** on the horizontal plane. The holding apparatus **13** is moved to the placing portion **50** at the transfer source, and the cover **51** and the placing portion **50** are coupled. Note that the pin support table **1113** performs an operation opposite to the separation operation to move the pins **1114** to the retreat positions.

By superposing the cover **51** on the placing portion **50**, they are coupled by magnetic force. The carrier **5** therefore becomes empty without holding the substrate W. The actuators **1102** are driven to move the positioning members **1103** apart from the placing portion **50**, thereby canceling the holding of the placing portion **50**.

The moving apparatus **14** moves the holding apparatus **13** holding the empty carrier **5** onto the transport apparatus **10**. The pivot unit **143** adjusts the rotation angle of the holding apparatus **13** on the horizontal plane. Subsequently, the suction of the chucking portions **1301** of the cover holding unit **130** is stopped to release the carrier **5** to the atmospheric pressure. The holding of the empty carrier **5** is thus canceled, and the empty carrier **5** is transferred to the transport apparatus **10**. The transport apparatus **10** unloads the empty carrier **5** to the storage apparatus **2**, and the new carrier **5** holding the substrate W is loaded from the processing apparatus **3** into the transport apparatus **10**.

The substrate W placed on the transport apparatus **12** is transferred to the processing apparatus **4** by the transport apparatus **12** and is processed by the processing apparatus **4**.

As described above, according to this embodiment, when transferring the substrate W from the carrier processing apparatus **11** to the transport apparatus **12**, the holding apparatus **13** holds and transports both the cover **51** and the substrate W. Compared to a method of separately moving the cover **51** and the substrate W, the number of transfer steps can be decreased to improve the transfer efficiency of the substrate W. The cover **51** and the substrate W are held adjacently with their surfaces being in postures parallel to each other. The cover **51** and the substrate W are moved while keeping this positional relationship on the carrier **5**. Switching of holding of the cover **51**, and the like become unnecessary, and the efficiency when returning the cover **51** onto the placing portion **50** can also be improved, in addition to the improvement of the transfer efficiency of the substrate W.

Second Embodiment

In the first embodiment, the substrate W is chucked in contact and held by negative-pressure suction by the chucking portions **1311** of the substrate holding unit **131**. Instead, non-contact chucking by the Bernoulli chuck method is also possible.

FIG. **14** is a partial exploded view showing a holding apparatus **13** according to this embodiment. FIGS. **15**A and **15**B are schematic views showing a substrate holding unit **133**. The holding apparatus **13** includes a cover holding unit **130**, the substrate holding unit **133**, and a support unit **132** that supports them. The arrangements of the cover holding unit **130** and support unit **132** are the same as those in the first embodiment.

The substrate holding unit **133** is a unit that holds a substrate W to freely cancel holding. The substrate holding unit **133** includes a base member **1330**, chucking portions **1331**, and regulating units **1332**. Attaching holes **1330***a* (two attaching holes **1330***a* are illustrated in this embodiment) in which support portions **1323** of the support unit **132** are fixed are formed in the base member **1330**. The base member **1330** is formed to avoid interference with positioning members **1103** of a positioning unit **110**.

Each chucking portion **1331** is arranged in a recessed portion of the lower surface of the base member **1330**. In this embodiment, three chucking portions are arranged at an interval in the longitudinal direction of the substrate. The chucking portion **1331** is connected to a fluid generation source (not shown) via a path formed inside the base member **1330**, and is configured to eject air. The air ejected from the chucking portions **1331** flows outside circumferentially from a gap between the lower surface of the base member **1330** and the substrate W. The air pressure at the gap between the chucking portions **1331** and the substrate W becomes lower than the atmospheric pressure, thereby chucking the substrate W in the non-contact manner.

Chucking of the substrate W is non-contact chucking, and the substrate W is freely movable in the substrate surface direction. Thus, the plurality of regulating units **1332** that regulate free movement of the substrate W in the substrate surface direction (horizontal direction in this embodiment) are arranged around each chucking portion **1331** provided at each end portion of the base member **1330** in the longitudinal direction. Each regulating unit **1332** includes a pin-like regulating portion **1332***a* projecting from the lower surface of the base member **1330**. The regulating portion **1332***a* is arranged to be able to project/retract from/to the main body of the regulating unit **1332**. The regulating portion **1332***a* projects from the lower surface of the base member **1330** in the Y direction to freely extend/contract.

The plurality of regulating units **1332** are arranged at an interval so that the regulating portions **1332***a* surround the edge of the substrate W. In this embodiment, six regulating units **1332** are arranged. More specifically, two regulating units **1332** on each of facing sides of the substrate W in the longitudinal direction, that is, a total of four regulating units **1332**, and one regulating unit **1332** on each of facing sides of the substrate W in the widthwise direction, that is, a total of two regulating units **1332** are arranged. When the substrate W moves in the substrate surface direction, the edge of the substrate W abuts against the respective regulating portions **1332***a*, and the free movement of the substrate W is regulated.

The operation of the substrate holding unit **133** during the transfer operation of the substrate W in this embodiment will be explained with reference to FIGS. **16**A to **18**.

FIG. **16**A shows a state in which pins **1114** push up a cover **51**. This state is equivalent to the stage of FIG. **10**A in the first embodiment. The regulating portions **1332***a* of the substrate holding unit **133** abut against the upper surface of a placing portion **50**, and the six regulating portions **1332***a* surround the substrate W. The substrate W and the cover **51** are spaced apart from each other. The regulating portions **1332***a* freely extend/contract. Hence, when the holding apparatus **13** is moved down onto the positioning unit **110**, the regulating portions **1332***a* abut against the upper surface of the placing portion **50**. When the holding apparatus **13** is further moved down, the regulating portions **1332***a* contract.

When ejection of air from the chucking portions **1331** starts, the substrate W is spaced apart from the placing portion **50**, as shown in FIG. **16**B, and is chucked to the lower surface of the base member **1330** in the non-contact manner. While regulating the periphery of the substrate W at the time of chucking in the non-contact manner, the regulating portions **1332***a* guide movement of the substrate W from the placing portion **50** to a non-contact chucking/holding position. Note that the cover **51** and the substrate W are held by the holding apparatus **13** in a state in which their facing surfaces contact each other at an overlapping portion. Subsequently, the moving apparatus **14** moves up the holding apparatus **13**. Both the cover **51** and the substrate W are held parallel to each other in the horizontal posture.

Then, as shown in FIG. **17**A, the moving apparatus **14** moves down the holding apparatus **13** onto the transport apparatus **12**. At the time of movement, the substrate W may

freely move in the substrate surface direction (Z direction). However, the regulating portions **1332***a* regulate this free movement.

As in the first embodiment, when the holding apparatus **13** is moved down onto the transport apparatus **12**, the projections **120** abut against the cover **51** and become a state in FIG. **17**B. When the ejection of air from the chucking portions **1331** is stopped, the chucking of the substrate W is canceled, and the substrate W is placed on the transport apparatus **12**. Even at this time, the regulating portions **1332***a* guide the movement of the substrate W until the substrate W is placed on the transport apparatus **12** while regulating the periphery of the substrate W. By these operations, the transfer of the substrate W to the transport apparatus **12** is completed.

After that, an operation of superposing the cover **51** on the placing portion **50** on the positioning unit **110** at the transfer source to empty the carrier **5**, and transferring the empty carrier **5** to a transport apparatus **10** is performed, as shown in FIG. **18**.

In this embodiment, the substrate W is held without contacting the substrate holding unit **133**, so it can be prevented to leave a chucking trace on the substrate W.

In a transfer system **1** according to this embodiment, the transport apparatus **10** and a carrier processing apparatus **11** are arranged at positions different in the Z direction. Alternatively, the carrier processing apparatus **11** may be arranged midway along the transport locus by the transport apparatus **10** so that the transport apparatus **10** and the carrier processing apparatus **11** are arranged at the same position in the Z direction. This makes it possible to continuously perform loading/unloading of the carrier **5**, separation between the placing portion **50** and the cover **51**, and holding of the substrate W and cover **51**.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2014-003675, filed Jan. 10, 2014, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. A holding apparatus that holds, from a carrier including a placing portion on which a substrate is placed, and a cover that is superposed on an upper surface of the placing portion in close contact, the substrate held between the placing portion and the cover, and the cover, comprising:

a cover holding unit configured to hold the cover;

a substrate holding unit configured to hold the substrate; and

a support unit configured to support said cover holding unit and said substrate holding unit,

wherein said support unit supports said cover holding unit to be able to displace said cover holding unit in directions in which said cover holding unit moves close to and apart from the carrier.

2. The apparatus according to claim **1**, wherein said support unit includes a floating mechanism configured to floatingly support said cover holding unit in the directions in which said cover holding unit moves close to and apart from the carrier.

3. The apparatus according to claim **1**, wherein said cover holding unit includes:

a chucking portion configured to chuck the cover; and

a cover regulating member configured to abut against the cover and regulate a position of the cover in a chucking direction.

4. The apparatus according to claim **1**, wherein said cover holding unit includes:

a chucking portion configured to chuck the cover; and

a positioning member configured to engage with the placing portion and position said cover holding unit with respect to the carrier.

5. The apparatus according to claim **1**, wherein said substrate holding unit includes:

a chucking portion configured to chuck the substrate in a non-contact manner; and

a regulating unit configured to regulate free movement of the substrate chucked in the non-contact manner in a substrate surface direction.

6. The apparatus according to claim **5**, wherein

said support unit includes a support portion configured to support said substrate holding unit, and

said regulating unit includes a regulating portion configured to project to freely extend/contract in a direction perpendicular to the substrate surface direction.

7. A transfer system that transfers, from a carrier including a placing portion on which a substrate is placed, and a cover that is superposed on an upper surface of the placing portion in close contact, the substrate held between the placing portion and the cover, comprising:

a positioning unit configured to position and hold the placing portion of the carrier;

a separation unit configured to separate the cover from the placing portion of the carrier held by said positioning unit;

a holding apparatus defined in claim **1**; and

a moving apparatus configured to move said holding apparatus.

8. The system according to claim **7**, wherein

said separation unit includes an abutment member configured to freely move up and down between a retreat position at which the abutment member is positioned below the placing portion of the carrier positioned by said positioning unit, and a working position at which the abutment member projects from the upper surface of the placing portion, and configured to abut against a lower surface of the cover of the carrier, and

said positioning unit includes a base member having an opening through which the abutment member can pass.

9. The system according to claim **7**, wherein

the transfer system further comprises:

a base portion on which said moving apparatus and said positioning unit are arranged; and

a transport apparatus arranged on said base portion and configured to transport the substrate, and

said moving apparatus supports said holding apparatus movably at least between said positioning unit and said transport apparatus.

10. The system according to claim **9**, wherein said moving apparatus includes:

a guide unit extending in a horizontal direction above said transport apparatus and said positioning unit;

a column supporting said guide unit;

a horizontally moving member configured to be movable along said guide unit; and

an elevating unit arranged on said horizontally moving member and configured to move up and down said holding apparatus.

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